Associations Between Global Population Health Indicators and Dialysis Variables in the Monitoring Dialysis Outcomes (MONDO) Consortium

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Key Words

Health indicators · Hemodialysis · End-stage renal disease · Renal replacement therapy

Abstract

Background: The number of patients receiving renal replacement therapy (RRT) increases annually and worldwide. Differences in the RRT incidence, prevalence, and modality vary between regions and countries for reasons yet to be clarified. **Aims:** Gain a better understanding of the association between hemodialysis (HD)-related variables and general population global health indicators. **Methods:** The present study included prevalent HD patients from 27 countries/regions from the monitoring dialysis outcomes (MONDO) database from 2006–2011. Global population health indicators were obtained from the 2014 World Health Organization report and the Human Development Index from the Human

Development Report Office 2014. The Spearman rank test was used to assess the correlations between population social economic indicators and HD variables. **Results:** A total of 84,796 prevalent HD patients were included. Their mean age was 63 (country mean 52–71), and 60% were males (country mean 52–85%). Significant correlations were found between HD demographic clusters and population education, wealth, mortality, and health indicators. The cluster of nutrition and inflammation variables were also highly correlated with population mortality, wealth, and health indicators. Finally, cardiovascular, fluid management, and dialysis adequacy clusters were associated with education, wealth, and health care resource indicators. **Conclusion:** We identified socio-economic indicators that were correlated with dialysis variables. This hypothesis-generating study may be helpful in the analysis of how global health indicators may interfere with access to HD, treatment provision, dialytic treatment characteristics, and outcomes.

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Introduction

Renal replacement therapy (RRT), namely hemodialysis (HD), peritoneal dialysis (PD), and kidney transplantation has been used since the 1940s to treat end-stage renal disease (ESRD) patients worldwide, and access to RRT is available in an increasing number of countries [1–4]. The number of patients on RRT has increased gradually, particularly in developing countries [5–8]. One of the most important reasons for this is because a broader population now has access to dialysis ensuring almost universal coverage including areas where previously patients had no access to treatment [7–9].

Differences in the RRT incidence, prevalence, and modality use vary broadly depending on region or country characteristics [10–12]. This can be partly explained by differences in social economic factors such as per capita gross domestic product (GDP), the proportion of GDP spend on health care, life expectancy at birth, and human development index (HDI) [9, 13–15]. The prevalence of RRT has increased particularly in countries with public health care systems and RRT insurance coverage, while the incidence increases independently of the degree of population coverage [9, 15, 16].

Patient characteristics and dialysis practices also vary widely between countries [17]. Despite the growing number of comprehensive reports on ESRD populations and dialysis treatments at national and international levels such as United States Renal Data System (USRDS) reports, the European Renal Association European Dialysis and Transplant Association (ERA-EDTA) reports, the Latin America Dialysis and Renal Transplant Registry (RLADTR), and Dialysis Outcomes and Practice Patterns Study (DOPPS) reports, there is still lack of information about the patterns of patient characteristics and dialysis variables in different areas of the world [18].

One of the most recent initiatives designed to improve our understanding of the epidemiology in patients with ESRD globally is the MONitoring Dialysis Outcome (MONDO) Initiative. MONDO, a consortium of multiple dialysis providers around the world, covering more than 40 countries, provides information about patients' demographic parameters, treatment characteristics, laboratory results, prescription data, as well as outcomes such as mortality and hospitalization [19, 20].

We hypothesize that global population health indicators may be associated with RRT access, treatment provision, dialytic treatment characteristics, and outcomes.

The aim of this study was to analyze the association between global population health indicators and ESRD patient profiles and characteristics in the MONDO cohort.

Methods

The study included prevalent ESRD patients undergoing maintenance HD from 27 countries/regions in the MONDO database from 2006 to 2011. Demographic and laboratory data were analyzed from dialysis unit records. Patients were considered prevalent when they survived at least one year on RRT. The average of years 1–3 on dialysis was computed for continuous variables. Data concerning socioeconomic status indicators from each participating country were obtained from the 2014 World Health Organization's (WHO) global health report; data concerning Human Development Index (HDI) were obtained from the Human Development Report Office (HDRO) [21, 22] (table 1).

HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and enjoying a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. The country classification according to HDI defines very high HDI ≥ 0.8 ; high HDI between 0.79 and 0.7; median HDI between 0.7 and 0.55, and low < 0.55 . All countries with HD patient information documented in the MONDO database and global health indicators documented in the WHO and HDRO reports were included in the analysis.

In total, we analyzed 40 dialysis-related and 52 socioeconomic variables. These 92 variables were grouped into 6 dialysis-related and 6 population socioeconomic clusters. The six dialysis-related clusters were (a) demographics, (b) comorbidities, (c) nutrition and inflammation, (d) anemia, (e) mineral metabolism and electrolytes, and (f) cardiovascular/fluid management/dialysis adequacy. The six global population health clusters were (a) demographics, (b) education, (c) wealth, (d) population risk factors, (e) health care resources, and (f) mortality. The variables included in the respective clusters are shown in (tables 2, 3).

Descriptive analyses for continuous variables were reported as mean, minimum and maximum, and standard deviations. For categorical variables, the percentage of each category was reported. The Spearman rank test was used to assess the correlations between social economic indicators and dialysis variables. A two-sided $p < 0.05$ was considered significant. In total, we computed 2,080 correlations. We then calculated the fraction of significant correlations ($p < 0.05$) per cluster. The fraction of significant correlations differed between clusters, ranging from 4.2 to 81.3%, with a median of 20%. Here we limit the presentation to HD clusters, which had at least 2 socioeconomic clusters with more than 20% of significant correlations. A correlation matrix plot was constructed to present the results. All the analyses were performed in R program – version 3.1.1.

Results

Data from 27 countries were used in these analyses. A total of 84,796 prevalent ESRD patients on HD were included. Their mean age was 63 years (country means 52–

Table 1. Socioeconomic indicators

Source	Description	Indicators
Demographic and socioeconomic statistics: (WHO 2012 in addition to data produced by a range of national and international organizations. Including the United Nations (ITU), UNDESA, UNESCO, UNICEF and the World Bank)	Presents data on demographic and socioeconomic factors that are major determinants of health.	Crude birth rate (per 1,000 population); Median age (years); Aged <15 years (%); Aged >60 years (%); Annual growth rate (%); Living in urban areas (%).
Human development index: (HDRO 2014)	Developed by the United Nations to measure and rank country levels of social and economic development based on four criteria: Life expectancy at birth; Mean years of schooling; Expected years of schooling; Gross national income per capita.	HDI
Life expectancy and mortality: (WHO 2012)	The estimates of mortality derived from death-registration data reported annually to WHO. It is based on sex- and age-specific death rates. Life expectancy at birth reflects the overall mortality level of a population and summarizes the mortality pattern that prevails across all age groups; children and adolescents, adults and the elderly.	Life expectancy at birth; life expectancy at age 60; neonatal mortality rate (the probability of death occurring during the first 28 days of life); infant and under-five mortality rates (the probability of dying between birth and 1 year of age, and before 5 years of age, respectively); and adult mortality rate (the probability of dying between 15 and 60 years of age).
Crude health and social indexes: (WHO 2014)		Crude birth rate (per 1,000 population); Crude death rate (per 1,000 population); Literacy rate among adults aged ≥ 15 years (%); Net primary school enrollment rate both males and females (%); Gross national income per capita (ppp int. \$); Population living on <\$1 (ppp int. \$) a day (%).
Population-risk factors: (WHO; data ranging from 2006 to 2012, majority in 2008)	Indicators for certain risk factors are associated with increased mortality and morbidity.	Pop. drinking water sources (%); Population sanitation (%); Prevalence of raised FBG (≥25 years) (%); Prevalence raised BP (≥25 years) (%); Adults ≥20 years obese (%); Alcohol consumption adults ≥15 years (liters of pure alcohol per person per year); Prevalence of smoking any tobacco product among adults ≥15 years (%); Prevalence of current tobacco use between 13–15 years (%).
Unemployed: (WFB estimated 2013)	Contains the percent of the labor force that is without jobs.	Unemployed Individuals (%).
Cause specific morbidity and mortality: (WHO 2012)	Derived from a range of sources of mortality, incidence and prevalence data. These include death-registration records, health-facility reports, household surveys, censuses, and special studies on deaths due to HIV.	Communicable conditions; Non-communicable conditions; Deaths caused by injuries (per 100,000 population).

Table 1. (continued)

Source	Description	Indicators
Health care resources: (WHO data ranging from 2001 to 2013). Data on the availability and consumer prices for selected generic medicines derived from surveys using WHO/HAI standard methods between 2001 and 2012.	Includes resources available to healthcare systems, such as: Workforce (physicians, nurses and midwives, psychiatrists other health-care workers). Infrastructure (hospitals, and hospital and psychiatric beds). Medical technologies and devices (radiotherapy, computed tomography, and mammography units).	Physicians (per 10,000 population); Nursing and midwifery personnel (per 10,000 population); Dentistry personnel (per 10,000 population); Pharmaceutical personnel (per 10,000 population); Psychiatrists (per 10,000 population); Hospitals (per 10,000 population); Hospital beds (per 10,000 population); Psychiatric beds (per 10,000 population); Computed tomography units (per million population); Radiotherapy units (per million population); Mammography units (per million female between 50 to 69 year); Total expenditure on health as % of GDP; Government expenditure on health as % of total; Private expend. on health as % of total; Government expenditure on health as % of total government expenditure; External resources for health as % of total expenditure on health; Social security expenditure on health as % of government expenditure on health; Out-of-pocket expenditure as % of private expenditure on health; Private prepaid plans as % of private expenditure on health.
Health expenditures: (These data are generated from information collected by WHO between 1999 and 2011). The most comprehensive data on health financing are generated from NHAs.	The data from (NHAs) collect expenditure information within an internationally recognized framework.	Total expenditure on health as % of gross domestic product; General government and private expenditure on health as % of total expenditure on health; External resources for health as % of total expenditure on health; Social security expenditure on health as % of general government expenditure on health; Out-of-pocket expenditure as % of private expenditure on health; Private prepaid plans as % of private expenditure on health.
Per capita health expenditures: (WHO 2012)	In US dollars (adjusted for ppp, which eliminates the differences in price levels between countries).	Per capita total expenditure on health at average exchange rate day (US\$); Per capita total expenditure on health (ppp int. US\$); Per capita government expenditure on health at average exchange rate (US\$); Per capita government expenditure on health (ppp int. \$).
Hong Kong Taiwan: (CIA the World Fact Book estimated 2014)	Data not available on WHO. Death rate for both sexes.	Age over 65% (instead of over 60%); Below the poverty line instead of population living on <1\$ a day (%).
WHO = World Health Organization; HAI = Healthy Life Expectancy; NHA = National Health Accounts; WFB = World Fact Book; ppp = purchasing power parity; UNITU = United Nations International Telecommunication Union; UNDESA = United Nations Department of Economic and Social Affairs; UNESCO = United Nations Educational, Scientific and Cultural Organization; UNICEF = United Nations Children's Fund; HDRO = Human Development Report Office; HDI = Human Development Index.		

Table 2. Socioeconomic clusters

Cluster	Abbreviation	Socioeconomic indicators
Demographics	B_Rte M_Age Age_blw_15 Age_abv_60 Gr_Rte Urban	Crude birth rate (per 1,000 population) Median age (years) Aged <15 years (%) Aged >60 years (%) Annual growth rate (%) Living in urban areas (%)
Education	Lit P_Sch	Literacy rate adults ≥15 years (%) Primary school enrolment rate (%)
Population risk factors	Water Sanit DM Hyp Obes Alc Smk_abv_15 Smk_blw_15	Population using improved drinking-water sources (%) Population using improved sanitation (%) Prevalence of raised fast blood glucose (≥25 years) (%) Prevalence raised blood pressure (≥25 years) (%) Adults ≥20 years obese (%) Alcohol consumption adults ≥15 years (liters of pure alcohol per person per year) Prevalence of smoking adults ≥15 years (%) Prevalence of tobacco use between 13 and 15 years (%)
Wealth	HDI GNI Pop_blw_1\$ Unempl	Human Development Index (HDI) Gross national income (ppp int. \$) Population living on <\$1/day (%) Unemployed (%)
Health care resources	MDs Nurses Dentists Pharm Psych Hosp Hosp_Beds Psych_Beds CT Rad_Th Mammo Hlth_Ex_T Hlth_Ex_Gov Hlth_Ex_Pri Hlth_Exp% Hlth_Ext Soc_Sec OOP Hlth_Ins Hlth_T_Exp\$ Hlth_PC_Exp Hlth_PC_Exp Gov\$ Pop	Physicians (per 10,000 population) Nursing and midwifery personnel (per 10,000 population) Dentistry personnel (per 10,000 population) Pharmaceutical personnel (per 10,000 population) Psychiatrists (per 10,000 population) Hospitals (per 10,000 population) Hospital beds (per 10,000 population) Psychiatric beds (per 10,000 population) Computed tomography units (per million population) Radiotherapy units (per million population) Mammography units (per million female between 50 to 69 years) Total expenditure on health as % of GDP Government expenditure on health as % of total Private expenditure on health as % of total Government expenditure on health as % of total government expenditure External resources for health as % of total expenditure on health Social security expenditure on health as % of government expenditure on health Out-of-pocket expenditure as % of private expenditure on health Private prepaid plans as % of private expenditure on health Per capita total expenditure on health at average exchange rate day (US\$) Per capita total expenditure on health (ppp int. \$) Per capita government expenditure on health at average exchange rate (US\$) Per capita government expenditure on health (ppp int. \$) Total population
Mortality	L_Exp_Brth L_Exp_60 Neo_Mort Inf_Mort Mort_blw_5yr Mort_Adlt CDR Morb_Mort	Life expectancy at birth (years) Life expectancy at age 60 (years) Neonatal mortality rate (per 1,000 live births) Infant mortality rate (per 1,000 live births) Under-five mortality rate (per 1,000 live births) Adult mortality rate (per 1,000 population) Crude death rate (per 1,000 population) Cause-specific mortality and morbidity (all causes – per 100,000 population)

Table 3. Dialysis clusters

Cluster	Abbreviation	Dialysis variables
Demographics	Age Male	Age Male (%)
Comorbidities (%)	DM CHF HTN Arr All CVD IHD CVD not HTN PAD/PVD Malign	Diabetes mellitus (%) Congestive heart failure Hypertension (%) Arrhythmia (%) All cardiovascular diseases (%) Ischemic Heart Disease (%) CVD other than HTN (%) Peripheral arterial disease/Peripheral venous disease (%) Malignancy (%)
Nutritional and inflammation	Alb Crea BMI Chol LDL-C HDL-C CRP WBC	Albumin (g/dl) Creatinine (mg/dl) Body mass index (kg/m ²) Cholesterol (mg/dl) Low density lipoprotein cholesterol (mg/dl) High density lipoprotein cholesterol (mg/dl) C-reactive protein (mg/l) White blood cells (1,000/mc)
Anemia	Hb Ferr TSAT	Hemoglobin (g/dl) Ferritin (ng/ml) Transferrin saturation index (%)
Mineral metabolism and electrolytes	Phos iPTH Ca HCO3 Na K	Phosphate (PO ₄ ⁻ mg/dl) Intact parathormone (pg/ml) Calcium (Ca ⁺² - mg/dl) Bicarbonate (HCO ₃ ⁻ - mEq/l) Sodium (Na ⁺ - mEq/l) Potassium (K ⁺ - mEq/l)
Cardiovascular, fluid management, and dialysis adequacy	Pre-SBP Pre-DBP Post-SBP Post-DBP IDWG% IDWG (kg) Pre-Wt Post-Wt Tx_Time Cath URR eKt/V	Pre-systolic blood pressure (mm Hg) Pre-diastolic blood pressure (mm Hg) Post-systolic blood pressure (mm Hg) Post-diastolic blood pressure (mm Hg) Interdialytic weight gain in % of post-HD body weight Interdialytic weight gain (kg) Pre-weight (kg) Post-weight (kg) Treatment time (min) Catheter (%) Urea removal ratio Equilibrated Kt/V

71), with the highest mean age in Hong Kong and the lowest in Russia. The mean percentage of males in this population was 61% (country means 52–85%) with the highest percentage in Sweden (85%) and the lowest in Taiwan (52%). The proportion of diabetic patients was

highest in the United States (54%) and lowest in Sweden (5%). The average percentage of others comorbidities and dialysis parameters per country is shown in tables 4–6.

Global population health indicators were extracted from the WHO 2014 report and from the HDRO report

Table 4. Percentage of HD patient comorbidities per country/regions

Country	Number of patients	DM	CHF	HTN	Arr	MI	IHD	CVD not HTN	PAD/PVD	All CVD	Malignancy
Australia	498	30					46		21	17	13
Bosnia	488	17	20	29	9		9	33	3	71	7
Czech Republic	1,738	6	1	28	11	1	6	11	2	34	9
France	1,516	15		4	2					4	1
Germany	11,591	41					41	38	30	63	16
Hungary	3,064	24		25	7		1	2		26	4
Hong Kong	136	40					33		7	10	13
Ireland	238	16		3				1		4	
Italy	1,881	26		11	4		5	7	1	17	4
South Korea	879	51					12		8	8	6
Malaysia	287	39					8		3	3	2
Poland	4,290	20	7	25	12	7	15	19	10	33	11
Portugal	6,152	31	1	24	8	1	9	15	2	37	5
Philippines	626	25					12		4	5	2
Romania	3,515	15		14	3		1	3	1	16	1
Russia	2,457	14	1	16	4		13	16	1	29	2
Serbia	322	19	2	30	6		9	17	4	56	3
Slovakia	993	36		12	5		3	5		16	3
Slovenia	281	25		27	14		4	6		32	10
Spain	7,936	24	1	34	13		3	9	1	43	6
Sweden	41	5			7						
Singapore	314	46					32		11	11	10
Turkey	7,260	33		9			3	3		12	1
Taiwan	8,304	54					12		12	7	4
Thailand	227	37					23		4	2	3
UK	5,436	18		2	1		1	2		4	
USA	14,326	54	17	50	6	2	12	32	10	58	4
Total	84,796										
Mean		28.2	6.25	20.2	7	2.75	13.04	12.88	7.11	23.77	5.83
Minimum		5	1	2	1	1	1	1	1	2	1
Maximum		54	20	50	14	7	46	38	30	71	16

Abbreviations are shown in table 3.

(table 1). Most countries in this analysis have very high (17 countries) or high (9 countries) HDI, while it is low in the Philippines. Significant correlations between global health indicators and dialysis variables are presented in a correlation matrix plot (fig. 1).

We found significant correlations between dialysis demographics cluster and mortality, wealth, and education clusters of population with a percentage of 81, 63, and 50% of correlations performed, respectively. The dialysis-related nutrition and inflammation cluster showed

Table 5. HD patient comorbidities (in %), countries combined

Variable	Number of countries	Mean	Minimum	Maximum
Diabetes	27	28	5	54
Congestive heart failure (CHF)	8	6	1	20
Hypertension (HTN)	17	20	2	50
All cardiovascular disease (CVD)	26	24	2	71
Arrhythmia (Arr)	16	7	1	14
Myocardial infarction (MI)	4	3	1	7
Ischemic heart disease	24	13	1	46
CVD not HTN	17	13	1	38
PAD/PVD	19	7	1	30
Malignancy (Malign)	24	6	1	16

Table 6. HD variables; countries combined

Variable	Number of countries	Mean	Minimum	Maximum	SD*
Age, years	27	63.13	52.55	71.75	4.09
Male gender, %	27	61	52	85	
Albumin, g/dl	27	3.81	3.53	4.10	0.14
Creatinine, mg/dl	27	7.91	6.48	10.27	0.97
BMI, kg/m ²	26	26.30	21.63	34.94	2.71
Cholesterol, mg/dl	18	170.00	139.40	188.40	13.64
LDL-C, mg/dl	17	96.68	66.95	119.10	12.26
HDL-C, mg/dl	17	45.40	35.18	53.89	4.29
CRP, mg/l	25	12.42	1.39	34.58	6.98
WBC, 1,000/mc	19	6.78	3.01	7.56	0.96
Hemoglobin, g/dl	27	11.12	10.04	12.49	0.58
Ferritin, ng/ml	27	503.50	291.20	764.90	128.50
TSAT, %	26	29.81	21.51	36.26	3.42
Phosphate, mg/dl	27	4.93	4.38	6.80	0.47
iPTH, pg/ml	26	318.30	48.88	1,197.20	210.70
Calcium, mg/dl	27	8.95	8.62	9.32	0.19
Bicarbonate, mEq/l	25	22.48	20.56	24.33	1.12
Sodium, mEq/l	27	137.60	135.90	139.10	0.83
Potassium, mEq/l	27	4.90	4.51	5.50	0.24
Pre-HD SBP, mm Hg	27	141.40	128.00	151.60	6.39
Pre-HD DBP, mm Hg	27	73.03	65.99	81.98	4.37
Post-HD SBP, mm Hg	27	134.40	116.00	158.70	8.39
Post-HD DBP, mm Hg	27	71.50	64.73	79.99	3.92
IDWG, % of post-HD weight	27	3.30	1.84	6.04	1.01
IDWG, kg	27	2.28	1.43	4.05	0.59
Pre-HD weight, kg	27	71.67	57.69	81.13	7.09
Post-HD weight, kg	27	69.62	55.52	79.56	7.29
Treatment time, min	27	240.50	213.10	270.20	13.88
Catheter, %	27	31	8	59	
URR, %	27	73.75	69.74	77.89	1.97
eKt/V	27	1.43	1.21	1.82	0.11

* Standard deviation.

Fig. 1. The correlation matrix of HD variables and socioeconomic indicators. Blue color indicates positive correlation; red color indicates negative correlation, the color intensity and the shape of the symbols are both indicators of the strength of the correlation

(square: correlation coefficient <0.54 ; circle: between 0.54 – 0.7 and star: ≥ 0.7). Green lines delineate the clusters. Only correlations with $p < 0.05$ are shown. Abbreviations are shown in tables 2 and 3.

a higher fraction of significant correlations with mortality (40%), wealth (31%), education (25%), and population-risk factors (25%). The dialysis-related anemia cluster was correlated with wealth (33%), health care resources (22%), mortality (21%), and population-risk factors (21%). The cardiovascular/fluid management/dialysis adequacy cluster correlated with education (41%), wealth (31%), and health care resources (25%). Other clusters did not show more than 20% of significant correlations.

Discussion

Differences in the RRT incidence, prevalence, and modality vary depending on socioeconomic status of the region. In 2009, Yoshino et al. reported on a global level the correlations between mortalities in the general and HD populations in the respective countries [13]. In the present study, we extend that analysis by exploring associations between global population health indicators and dialysis variables in the international MONDO HD patient cohort.

Patient demographics, anemia, nutrition, and cardiovascular assessment were HD clusters with large numbers of significant correlations associated with clusters of global health indicators.

Mortality, wealth, education, and health care resources indices were significantly correlated with the demographic dialysis cluster. The demographic variables associated with global health indicators included particularly age and percentage of males. These findings corroborate reports from the general population, since age, gender, and race are directly related to mortality, wealth, education, and health care resources [21, 22]. The positive correlation coefficients between HD demographics and mortality (represented by life expectancy at birth and life expectancy at 60 years of age) could reflect an increase in access to RRT around the world, as well as an improvement in access to pre-dialysis care which delays HD initiation and extends survival [1–9]. The gross national income (GNI) from wealth cluster, the percentage of primary school enrolment in the general population, from education cluster, and the per capita total expenditure on health (US\$), and per capita government expenditure on health (PPP int. \$) from health care resources cluster were all positively correlated with the demographic cluster in dialysis population. RRT is an expensive therapy and can be responsible for 1–2% of health care expenditure in high income countries [23, 24]. Data from EVEREST study already showed the incidence of patients starting RRT is influenced by some certain macroeconomic factors including national wealth and economic structure [14, 15].

Particularly albumin and LDL cholesterol (LDL-C) as nutritional and inflammatory parameters (which are usually related to each other [24]) showed significant correlations with mortality, wealth, education, and population-risk factors. Albumin is a surrogate marker of nutrition and inflammation strongly associated with HD mortality [25]. In a large international study of the MONDO cohort, Usvyat et al. showed a significant decrease of albumin levels in HD patients a few months before death [26]. LDL-C is more closely related to vascular calcification and the risk increase for arteriosclerosis and cardiovascular diseases, the leading cause of death in HD [27, 28]. Notable are the negative correlations between albumin and LDL-C with life expectancy at birth, life expectancy at 60 years, HDI and gross national income (GNI), and also between LDL-C and primary school enrolment.

The anemia cluster was highly correlated with wealth, health care resources, population risk factors, and mortality clusters. The hemoglobin (Hb) level was the prin-

ciple variable and was positively correlated with HDI and GNI and negatively correlated with poverty. Hb was also positively correlated with the number of physicians, nurses, pharmacists, dentists, and many variables related with health care expenditure, as well as with the population-risk factors percentage of population drinking water and sanitation. On the other hand, Hb levels were generally negatively correlated with mortality cluster variables neonatal death, death below age 5, and adult mortality. Anemia is associated with mortality rate in the general population at different ages and can be related to diseases such as ESRD, malignancy, and heart disease [29, 30]. An effective treatment for anemia in ESRD patients depends on the availability of expensive medications, such as erythropoiesis stimulating agents (ESAs) and intravenous iron. Provision of these may be scarce in some countries when the consequence Hb target levels cannot be achieved and may affect patient outcomes [31, 32].

Finally, the variables of the cluster ‘cardiovascular, fluid management and dialysis adequacy’ were strongly correlated with the education, wealth and health care resources clusters. Some studies have shown that the degree of literacy is associated with dialysis outcomes [33]. The cardiovascular, fluid management and dialysis adequacy cluster and the education cluster as represented by literacy and primary school enrolment were negatively correlated. Some examples from the cardiovascular, fluid management, and dialysis adequacy cluster are the significant correlations of the lower IDWG and better blood pressure control with the higher degree of literacy and primary school enrolment. A positive correlation between HD prevalence and wealth was previously described, showing that the lower the GPD (under US\$ 10,000), the higher the prevalence of ESRD [6, 7]. Wealth can also interfere in the patient’s treatment compliance [34]. Here HDI and GNI were negatively correlated with pre- and post-dialysis diastolic blood pressure, and positively correlated with pre- and post-dialysis weight and percentage of dialysis catheters. Modality choice, patient outcomes, and survival in dialysis population can be related to many health care resource indicators, such as pre-dialysis health care access, health care system sophistication (insurance or public health system coverage), number of healthcare personnel and facilities, social security support, and percentage of GDP spent on health care [35–44]. In this study, some negative correlations were found between blood pressures variables and health expenditure, and also between IDWG and percentage of physicians and nurses in the general population.

This study has several limitations. First, the MONDO database does not comprise all HD patients of a given country. Consequently, the correlational analysis is incomplete. Second, the absence of some biologically plausible associations may reflect the heterogeneity of this group (27 countries). Third, testing for multiple correlations may result in spurious correlations. Fourth, some data are missing from the MONDO data base, especially comorbidity data. Fifth, socioeconomic indicators were not available from all countries. Sixth, we did not have the data to compare country-specific general population and MONDO data during the same years. Nevertheless, we believe that our study has merits. For the first time, we were able to study the associations between the characteristics of prevalent HD patients and health and macroeconomic factors in the respective background population of 27 countries. We were able to explore 40 dialysis variables and 52 global health indicators for the presence or ab-

sence of associations in over 85,000 HD patients. The study provides a panoramic view of the interrelationship between socioeconomic factors, access to RRT, and patient comorbidities, and outcomes.

This hypothesis-generating study may stimulate future analysis of how global health indicators may interfere in RRT access, treatment provision, dialytic treatment characteristics, and outcomes.

Disclosure Statement

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