**Hemodialysis Use and Practice Patterns: An International Survey Study**

Htay Htay, MBBS[1]; Aminu K Bello, MBBS[2]; Adeera Levin, MD[3]; Meaghan Lunney, MSc, PhD[4]; Mohamed A Osman, MD[2]; Feng Ye, MSc[2]; Gloria E Ashuntantang, MD[5]; Ezequiel Bellorin-Font, MD[6]; Mohammed Benghanem Gharbi, MD[7]; Sara N Davison, MD[2]; Mohammad Ghnaimat, MD[8]; Paul Harden, MD[9]; Vivekanand Jha, MD[10,11]; Kamyar Kalantar-Zadeh,,MD[12]; Peter G Kerr MBBS, PhD[13,14]; Scott Klarenbach, MSc[2]; Csaba P Kovesdy, MD[15]; Valerie A Luyckx, MBBCh, PhD[16,17] Brendon Neuen, MD[18]; Donal O'Donoghue, MD[19,20] Shahrzad Ossareh, MD[21], Jeffrey Perl, MD[22,23]; Harun Ur Rashid, MBBS, PhD[24]; Eric Rondeau, MD, PhD[25,26]; Emily J See, MBBS[27,28]; Syed Saad, BSc[2]; Laura Sola, MD[29]; Irma Tchokhonelidze, MD[30]; Vladimir Tesar, MD, PhD[31]; Kriang Tungsanga, MD[32,33]; Rumeyza Turan Kazancioglu, MD[34]; Angela Yee-Moon Wang, MD, PhD[35]; Chih-Wei Yang, MD[36]; Alexander Zemchenkov, MD, PhD[37,38]; Ming-hui Zhao, MD, PhD[39,40,41,42]; Kitty J Jager, MD, PhD[43]; Fergus J Caskey, MD[44,45]; Vlado Perkovic, MBBS, PhD[46]; Kailash K Jindal, MBBS[2]; Ikechi G Okpechi, MBBS, PhD[2,47,48,]; Marcello Tonelli, MD[49,50]; David C Harris, MD[51]; David W Johnson, MBBS, PhD[52,53,54]

[1]Department of Renal Medicine, Singapore General Hospital, Singapore; [2]Division of Nephrology and Immunology, Department of Medicine, University of Alberta, Edmonton, Alberta, Canada; [3] Division of Nephrology, Department of Medicine, University of British Columbia, Vancouver, British Columbia, Canada; [4] Department of Community Health Sciences, University of Calgary, Calgary, Alberta, Canada; [5] Faculty of Medicine and Biomedical Sciences, Yaounde General Hospital, University of Yaounde I, Yaounde, Cameroon; [6] Division of Nephology and Hypertension, Department of Medicine, Saint Louis University, Saint Louis, Missouri, USA; [7] Urinary Tract Diseases Department, Faculty of Medicine and Pharmacy of Casablanca, University Hassan II of Casablanca, Casablanca, Morocco; [8] Nephrology Division, Department of Internal Medicine, The Specialty Hospital, Amman, Jordan; [9] Oxford Kidney Unit, Oxford University Hospitals NHS Foundation Trust, Oxford, UK; [10] George Institute for Global Health, UNSW, New Delhi, India; [11] Manipal Academy of Higher

Education, Manipal, India; [12] Division of Nephrology and Hypertension and Kidney Transplantation, University of California Irvine Medical Center, Orange, California, USA; [13] Department of Nephrology, Monash Medical Centre, Monash Health, Clayton, Victoria, Australia; [14] Department of Medicine, Monash University, Clayton, Victoria, Australia; [15] University of Tennessee Health Science Center, Memphis, Tennessee, USA; [16] Institute of Biomedical Ethics and the History of Medicine, University of Zurich, Zurich, Switzerland; [17] Renal Division, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, USA; [18] The George Institute for Global Health, Newtown, New South Wales, Australia; [19] Salford Royal NHS Foundation Trust, Salford, UK; [20] University of Manchester, Manchester, UK; [21] Division of Nephrology, Department of Medicine, Hasheminejad Kidney Center, Iran University of Medical Sciences, Tehran, Iran; [22] Division of Nephrology, St. Michael's Hospital and the Keenan Research Centre in the Li Ka Shing Knowledge Institute, St. Michael's Hospital, Toronto, Ontario, Canada; [23] Division of Nephrology, Department of Medicine, University of Toronto, Toronto, Ontario, Canada; [24] Department of Nephrology, Kidney Foundation Hospital and Research Institute, Dhaka, Bangladesh; [25] Intensive Care Nephrology and Transplantation Department, Hopital Tenon, Assistance Publique-Hopitaux de Paris, Paris, France; [26] Sorbonne Université, Paris, France; [27] Department of Intensive Care, Austin Health, Melbourne, Australia; [28] School of Medicine, University of Melbourne, Melbourne, Australia; [29] Dialysis Unit, CASMU-IAMPP, Montevideo, Uruguay; [30] Nephrology Development Clinical Center, Tbilisi State Medical University, Tbilisi, Georgia; [31] Department of Nephrology, General University Hospital, Charles University, Prague, Czech Republic; [32] Department of Medicine, Faculty of Medicine, King Chulalong Memorial Hospital, Chulalongkorn University, Bangkok, Thailand; [33] Bhumirajanagarindra Kidney Institute, Bangkok, Thailand; [34] Division of Nephrology, Bezmialem Vakif University, Istanbul, Turkey; [35] Department of Medicine, The University of Hong Kong, Queen Mary Hospital, Hong Kong; [36] Kidney Research Center, Department of Nephrology, Chang Gung Memorial Hospital, Chang Gung University College of Medicine, Taoyuan, Taiwan; [37] Department of Internal Disease, Clinical Pharmacology and Nephrology, North-Western State Medical University named after I.I. Mechnikov, Saint Petersburg, Russia; [38] Department of Nephrology and Dialysis, Pavlov First

Saint Petersburg State Medical University, Saint Petersburg, Russia; [39] Renal Division, Department of Medicine, Peking University First Hospital, Beijing, China; [40] Key Lab of Renal Disease, Ministry of Health of China, Beijing, China; [41] Key Lab of Chronic Kidney Disease Prevention and Treatment, Ministry of Education of China; Beijing, China; [42] Peking-Tsinghua Center for Life Sciences (CLS), Beijing, China; [43] ERA-EDTA Registry, Department of Medical Informatics, Academic Medical Center, Amsterdam Public Health Research Institute, University of Amsterdam, Amsterdam, the Netherlands; [44] Population Health Sciences, University of Bristol, Bristol, UK; [45] Renal Unit, Southmead Hospital, North Bristol NHS Trust, Bristol, UK; [46] The George Institute for Global Health, University of New South Wales Sydney, Sydney, New South Wales, Australia; [47] Division of Nephrology and Hypertension, University of Cape Town, Cape Town, South Africa; [48] Kidney and Hypertension Research Unit, University of Cape Town, Cape Town, South Africa; [49] Department of Medicine, University of Calgary, Calgary, Alberta, Canada; [50] Pan-American Health Organization/World Health Organization's Collaborating Centre in Prevention and Control of Chronic Kidney Disease, University of Calgary, Calgary, Alberta, Canada; [51] Centre for Transplantation and Renal Research, Westmead Institute for Medical Research, University of Sydney, Sydney, New South Wales, Australia; [52] Centre for Kidney Disease Research, University of Queensland, Brisbane, Australia; [53]Translational Research Institute, Brisbane, Australia; [54] Metro South and Ipswich Nephrology and Transplant Services (MINTS), Princess Alexandra Hospital, Brisbane, Australia

**Address for correspondence**

Professor David Johnson

Department of Nephrology, Level 2, ARTS Building,

Princess Alexandra Hospital

199 Ipswich Road, Woolloongabba, Brisbane Qld 4102 AUSTRALIA

Tel: +61 7 3176 5080, Fax: +61 7 3176 5480

Email: david.johnson2@health.qld.gov.au

**Abstract**

**Rationale & Objective:** Hemodialysis (HD) is the most common form of kidney replacement therapy. The study aimed to examine the use, availability, accessibility, affordability and quality of HD care worldwide.

**Study Design:** A cross-sectional survey

**Setting & Participants:** Stakeholders (clinicians, policymakers, consumer representatives) in 182 countries were convened by the International Society of Nephrology between July to September 2018.

**Outcomes:** Use, availability, accessibility, affordability and quality of HD care

**Analytical Approach:** Descriptive statistics

**Results:** Overall, representatives from 160 countries (88%) participated. Median country-specific use of chronic HD was 298.4 (interquartile range: 80.5–599.4) per million population (pmp). The global median HD use among new kidney failure patients was 98.0 (81.5–140.8) pmp and the median number of HD centers was 4.5 (1.2–9.9) pmp. Adequate HD services (3-4 hours, 3 times weekly) were generally available in 27% of low-income countries. Home HD was generally available in 36% of high-income countries. Thirty-two percent of countries performed monitoring of patient-reported outcomes, 61% of small solute clearance, 60% of bone mineral markers, 51% of technique survival, and 60% of patient survival. At initiation of chronic dialysis, only 5% of countries used arteriovenous access in most patients. . Dialysis access education was suboptimal, funding for vascular access procedures was not uniform, and co-payments were greater in countries with lower levels of income. Patients in 23% of the low-income countries had to pay >75% of HD costs, compared with patients in only 4% high-income countries.

**Limitations:** A cross-sectional survey with possibility of response bias, social desirability bias, and limited data collection preventing in-depth analysis

**Conclusions**: In summary, findings reveal substantial variations in global HD use, availability, accessibility, quality and affordability worldwide, with the lowest use evident in low and lower-middle-income countries.

**Key words**: Accessibility to hemodialysis, Affordability, Availability of hemodialysis; ESKD care, Quality of HD services, Funding for HD services

**Plain Language Summary:**

Hemodialysis is the main life-support therapy for patients with kidney disease. This international survey administered by the International Society of Nephrology aimed to examine the epidemiology of kidney failure patients on hemodialysis worldwide, availability of hemodialysis in each country, proportion of patients on dialysis at the onset of kidney failure, and funding for hemodialysis.

The literature search and the survey responses by key stakeholders (nephrologists, policy makers) from 160 countries suggested a wide variation in the use of hemodialysis worldwide with limited access to hemodialysis mainly in low and lower-middle-income countries. Similarly, funding for hemodialysis treatment varied substantially with patients from low and lower-middle-income countries generally bearing higher out-of-pocket expenses. The survey also noted differences in the practice patterns of hemodialysis globally.

## Introduction

Although kidney replacement therapy (KRT) is essential for treating patients with kidney failure, many patients (particularly those in low and lower-middle income countries), do not have access to KRT.[1] In a previous systemic review, Liyanage et al. reported that substantial numbers (at least 2. 28 million) of patients with kidney failure did not have access to KRT and might have died prematurely.[2] These numbers are expected to increase with time in parallel with population growth and aging around the world.[3]

Hemodialysis (HD) remains the primary mode of KRT for kidney failure patients in most countries worldwide, and accounts for 90% of all dialysis globally.[4] Compared with peritoneal dialysis, HD is more challenging from a technical perspective and often more expensive.[4] Despite its widespread utilization, very little information is available on access to and quality of maintenance HD care for patients with kidney failure worldwide.[1,2,4,5]

The first Global Kidney Health Atlas (GKHA) reported the number of countries with HD capacity[6]. The present study is specifically aimed at examining the incidence, prevalence, availability, accessibility, affordability and quality of HD care for patients with kidney failure around the world.

## Methods

### *Data collection*

This study is based on data from the 2019 edition of GKHA survey, a cross-sectional study of the global access and treatment characteristics of kidney failure care conducted by the International Society of Nephrology (ISN). The study was approved by the University of Alberta Research Ethics Committee and all participants provided informed consent. The methods have been discussed in detail elsewhere.[7] In short, two approaches, including desk research and the GKHA survey, were used to gather the data for the study. The desk research was literature searches that were conducted in collaboration with an information

specialist to synthesize global data on the epidemiology and treatment of kidney failure. These data were extracted from key reports including United States Renal Data System (USRDS), European Dialysis and Transplant Association (ERA-EDTA) registry, Australia and New Zealand Dialysis and Transplant (ANZDATA) registry, and other relevant published and gray literature. Cost of maintenance HD was obtained from a scoping review. The GKHA survey was conducted using an online questionnaire (supplementary Appendix 1).[8] All countries with kidney societies were invited to participate in the survey. Three key opinion leaders from each country, including a leader or president of a nephrology society, a leader of a consumer representative organization, and a policymaker, were purposefully identified by project leaders of each region. Project leaders were identified via international contacts, collaborators, ISN leaders and regional board members, who played crucial roles to ensure: (a) appropriate identification of key opinion leaders in each country, (b) organization and follow-up on responses from all countries within a specific world region, (c) attainment of additional data sources and contacts for surveys where required, and (d) provision of support to review regional data as needed. Key stakeholders identified by project leaders were subsequently sent invitations to participate in the survey (available in English, French, Spanish) which included a link to the survey's online portal (www.redcapcloud.com). The survey was conducted from July to September 2018.

*Definition*

The present study examined the global use of chronic HD, availability (defined as generally available if HD is available in ≥ 50% centers, hospitals or clinics, or generally not available if HD is available in <50% of centers, hospitals or clinics as a treatment option for kidney failure patients in a country), global HD centers density, accessibility (defined as the proportion of kidney failure patients able to access dialysis at the onset of kidney failure in a country), within-country variation in access to dialysis, affordability (defined as the proportion of the HD treatment cost paid for directly by the patient ), dialysis access on HD initiation, and availability of services for kidney failure care using data extracted from key reports and the GKHA survey.

*Statistical analysis*

The data are presented as frequencies (percentages) for categorical variables, medians (interquartile ranges), and ranges for continuous variables. Survey data were analyzed and stratified based on the 4 World Bank income groups and the 10 ISN regions. The results of the online survey were reported in accordance with the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guidelines.[9] The data were analyzed using Stata 14 software (Stata Corporation).

## Results

### *Characteristics of participating countries*

Out of 182 countries contacted, 160 (88%), including 58/66 high, 41/48 upper-middle, 38/42 lower-middle and 23/26 low-income countries, responded to items designed to assess the various domains of access to and quality of maintenance HD for kidney failure patients. By ISN region, data were collected from 42 countries in Africa, 19 countries in Eastern and Central Europe, 18 countries in Latin America, 11 countries in the Middle East, 10 countries in the NIS and Russia, 10 countries in North America and the Caribbean, 7 countries in North and East Asia, 15 countries in Oceania and South East Asia, 7 countries in South Asia, and 21 countries in Western Europe. Overall, 317 participants, including nephrologists (n=260, 82%), non-nephrologist physicians (n=22,7%), other health professionals (n=7, 2%), administrators/policymakers/civil servants (n=17, 5%), and others (n=11, 3%) responded to the survey (Table S1).

### *The global chronic HD use*

Overall, data for this item were available from 126 countries (Table 1). The median global use of chronic HD patients was 298.4 (interquartile range [IQR]: 80.5–599.4) per million population (pmp), but varied widely across countries, from 0.3 pmp in the Democratic Republic of Congo to 2148 pmp in Japan (Table

1). The HD population was very low in low-income countries, for example, 5.8 pmp in Ethiopia, 2.8 pmp in Zimbabwe and 0.5 pmp in Tanzania.

Data of HD use among new kidney failure patients were available from 26 countries. Of these countries, the median use was 108.8 (81.5–150.1) pmp(Table 1). No such data were available for lower-middle and low-income countries. Only 1 country in North and East Asia reported the use of HD among new kidney failure patients.

***Availability of chronic HD service***

The GKHA questionnaire included a single-item question asking respondents if chronic HD (adult and pediatric) was available in their country. Overall, 156 countries responded to the survey, and all participating countries (100%) reported that chronic HD service was available.

***Density of HD centers***

The questionnaire also asked respondents how *many* centres in their country provided chronic HD. Overall, 154 countries responded to this item. The median (interquartile range) number of centers providing maintenance HD was 4.5 (1.2–9.9) pmp (Table 2). HD centre density was extremely low in low-income countries; 0.13 pmp in Chad, 0.17 in Uganda, and 0.18 pmp in Ethiopia.

***Availability of HD***

Overall, 154 countries responded to survey items designed to assess the availability of HD. Of these, 129 countries (84%) indicated that HD service was generally available (in ≥ 50% of hospitals or centers in a country). Most low-income countries (15/22) reported <50% of hospitals providing HD services in a country (Table 2).

*Adequate frequency of center-based HD services*

A total of 118/154 countries (77%) reported that HD services (3 to 4 hours, thrice weekly) were generally available (≥ 50% of centers) in their countries. This proportion ranged from 53/56 (95%) in high-income to 6/22 (27%) in low-income countries. (Figure S1).

*Home-based HD services*

Overall, 20/154 countries (13%) reported that home-based HD services were generally available (≥ 50% of centers), whereas 49/154 countries (32%) reported that they were generally unavailable (<50% of centers).. Home-based HD service was not available in 85/154 (55%) of countries (Figure S2).

*Affordable patient transport services for dialysis*

Overall, 67/154 countries (44%) indicated that affordable patient transport services for dialysis were generally available (≥ 50% of centers) in their countries. This proportion ranged from 43/56 (77%) of high-income countries to 2/22 (9%) of low-income countries. This service was never available in 24/154 countries (16%).

***Accessibility of dialysis at the onset of kidney failure***

Data for accessibility of dialysis were provided by 154 countries (Table 2). In general, 108/154 (70%) reported that the majority (> 50%) of kidney failure patients had access to dialysis. However, low-income countries reported very limited access to dialysis at the onset of kidney failure (Table 2).

*Within-country variation in access to dialysis*

Overall, 94/154 (61%) participating countries reported no within-country variation in access to dialysis. This figure varied by income group (high: 53/56, 95%; upper-middle: 23/41, 56%; lower-middle: 14/35, 40%; low: 4/22, 18%). Overall, 122/154 (79%) countries reported no variation in dialysis access based on patients' characteristics (e.g., age, gender, employment status).

***Affordability of HD service***

Data for national average co-payments (including medications but no other ancillaries) for HD patients were obtained from 154 countries (Table 3). In general, people from high-income countries paid less or did not require co-payment for HD costs whereas people from low-income countries like Ethiopia, Sierra Leone and Chad had to pay 100% of HD costs out-of-pocket, and people from Madagascar, Zimbabwe, Burkina Faso, Democratic Republic of the Congo and Haiti had to pay >75% of HD costs out-of-pocket.

*Within-country variation in co-payments for HD services*

Overall, 116/154 (75%) of participating countries reported no within-country variation in co-payments for HD services. This percentage varied by country income level, namely 93% of high, 68% of upper-middle, 74% of lower-middle and 45% of low-income countries. Overall, 103/154 (67%) countries reported no variation in HD co-payments based on patients' characteristics, including age, gender and employment status.

*Funding for dialysis access creation in HD*

A total of 159 countries responded to this item. Of these countries, 61 (38%) countries reported that catheter insertion costs for HD were fully paid by the government (Figure S3). Overall, 64 (40%) countries reported that the costs for arteriovenous fistulas or grafts were fully covered by the government (Figure S4). The healthcare system's coverage for dialysis access creation varied by country income level. People from low-income countries including Uganda, Madagascar, Guinea, Zimbabwe, Haiti, Chad, and Niger had to pay solely private or out-of-pocket for vascular access procedures (central venous catheter insertion or creation of fistula/graft) for HD.

*HD cost*

The data for maintenance HD cost were obtained from 97 countries (Table 3). The global median annual HD cost was 22,616.8 (2016 USD) with a wide variation from 1560.0 USD in Cameroon to 103,186.6 USD in the Netherlands.

***HD quality***

Overall, 144 countries contributed data to this domain. (Figure 1, Figure S5). HD quality of countries was assessed by examining the proportion of centers routinely monitoring the following outcomes or parameters in a country.

*Monitoring of patient-reported outcomes*

Globally, 15% (n=22) of participating countries did not monitor patient-reported outcomes, whereas 32% (n=46) of countries reported that almost all (> 75%) HD centers performed such monitoring (Figure S5).

*Blood pressure monitoring*

A majority (86%) of countries monitored blood pressure in almost all (>75%) HD centers. Only 8% (n=11) of countries reported no monitoring of blood pressure in HD centers.

*Small solute clearance monitoring*

Most countries (n=88, 61%) monitored small solute clearance in almost all (> 75%) HD centers, whereas small solute clearance was not monitored in 12% (n=17) of countries. By country income level, monitoring solute clearance in almost all HD centers varied from 87% of high-income countries to 28% of low-income countries.

*Monitoring of hemoglobin*

Overall, 88% of countries monitored hemoglobin in almost all (> 75%) HD centers. By country income level, this proportion varied from 98% of high-income countries to 71% of low-income countries. However, 6% of countries did not monitor hemoglobin in any of their centers.

*Monitoring of bone mineral markers*

A majority (60%, n=86) of countries monitored bone mineral markers in almost all (> 75%) HD centers. By country income level, this proportion varied from 85% of high-income countries to 17% of low-income countries, whereas 8% (n=11) of countries did not monitor them at all.

*Monitoring of technique and patient survival*

Overall, technique survival and patient survival were monitored in almost all (>75%) HD centers in 51% (n=73) and 60% (n=86) of countries, respectively. These proportions varied across country income groups, ranging from 17% to 81% for technique survival and 22% to 89% for patient survival. However, technique and patient survival were not monitored in 12% (n=17) and 8% (n=12) of countries, respectively.

***Dialysis access for HD***

A total of 152 countries provided information about dialysis access. In general, only 17% (n=26) of participating countries reported having a majority (> 50%) of patients with kidney failure initiating dialysis using functioning vascular access (arteriovenous fistula or graft) (Figure S6). A considerable number of countries (n=69, 46%) reported having a majority (>50%) of patients with kidney failure initiating dialysis using a temporary catheter.

Education on choice of dialysis access and timing of access creation  education was not provided in Afghanistan, Azerbaijan, The Gambia, or Sierra Leone, and only 61 countries (41%) reported that a majority (>50%) of patients routinely received education about the best means of access and timely surgery for access creation.

**Discussion**

The GKHA is the largest international survey ever conducted in nephrology. The findings demonstrate marked variations and large disparities in the HD population  availability, accessibility, affordability and quality of HD care provided within and between different countries around the world.

The present study including data from all available national renal registries and published literature thereby provided a broader coverage of the epidemiology of kidney failure and dialysis than the USRDS database in which the data for low-income countries were not reported under the USRDS international comparisons. The findings from this study reveal substantial (>130-fold) variation in HD population between low and high-income countries, and a remarkable lack of these data, particularly in lower-middle and low-income countries. Health information and renal registries play a critical role in defining the burden of kidney failure, monitoring the quality and outcomes of kidney failure care, and more importantly, helping to better inform healthcare-related policymaking and health services planning.[10–12] A lack of or limited availability and quality of kidney registries in these under-resourced countries[13] prevents proper understanding of the true epidemiology of people with kidney failure, which further impedes informed guidance for the allocation of limited available resources to kidney failure care. To close this gap, establishing robust health information systems, including dialysis registries, is crucial. The ISN has established the "Sharing Expertise to support the set-up of Renal Registries" (ShareE-RR) initiative to support the development and maintenance of renal registries worldwide by providing a way to share registry resources. [14]

HD was provided in facilities in most countries; home HD services were generally unavailable, except in a small proportion of high-income countries. Although HD was available in all participating countries, access to this dialysis modality at the onset of kidney failure was highly variable and generally decreased as country income level decreased. Even if patients were able to access dialysis, most low income and African countries were unable to provide treatment with adequate frequency. The main predictor of access was the wealth of the individual country and the amount of resources each country spent on kidney failure care, such as HD.[1,15–17] In a universal health care coverage system, dialysis should be made available to the people who need it in an equitable manner, regardless of their financial status. In practice, however, we found that funding strategies for HD services around the world were diverse, with primarily public funding in high and upper-middle-income countries, but primarily private or out-of-pocket funding

in lower-middle and low-income countries with co-payments in excess of 75% of total HD costs were borne by patients in a quarter of all low-income countries Consequently, many patients in low income countries were at high risk of financial ruin if they accessed HD.[18] This resulted in inequity of access to HD services, particularly in lower-middle and low-income countries.

Increasing the global accessibility and quality of HD for people with kidney failure through more affordable and sustainable models of HD care is therefore of paramount importance. The ISN recently published suggested financial strategies and funding models to achieve equitable kidney failure care around the world.[19] One of these strategies involved the utilization of health technology assessments to evaluate the cost-effectiveness and clinical benefits of available KRT (including HD). Doing so helps direct limited funding resources toward the most cost-effective KRT option that could also provide acceptable clinical effectiveness for all patients.[19–21] Appropriate governance and health system organizational factors also need to be put in place to ensure equitable use of expensive HD resources. In addition, the financing model should allocate resources for HD ancillary costs (particularly vascular access), registries, workforce training, and early detection and management of CKD to prevent or reduce the incidence of kidney failure.[19] Defining minimum appropriate standards for HD service delivery may also help establish more sustainable models of care that maximize utilitarian gain for people with kidney failure.

The widely variable accessibility of dialysis observed between countries in the present study was often linked to local health workforce capacities. Workforce shortages were common in low and lower-middle income countries where dialysis accessibility was generally the lowest and kidney failure growth rates were generally the fastest.[1,2,15] Understanding facilitators of and barriers to the development of the health workforce and evaluating training and educational needs is clearly important to enhance the availability and utility of dialysis. Moreover, developing innovative, alternative models of workforce care through task substitution, telemedicine, mHealth and web-based education systems may help maximize the efficiency of the available workforce for HD service delivery.[19,22]

Apart from making HD more accessible and affordable, it is also important to ensure that HD treatments align with standardized safety practices and yield acceptable quality outcomes based on available evidence and guidelines.[23,24] Unfortunately, findings from the present study show that many recognized dialysis quality indicators were not routinely monitored, particularly in lower-middle and low-income countries. In the context of limited resources, it can be challenging to follow all of the standardized practices used in high-income countries and still meet fiscal responsibilities. Nevertheless, low and middle income countries should adapt existing guidelines to local settings using available validated tools, such as the ADAPTE framework,[25] to ensure delivery of safe, high quality dialysis.[19] Recently, the International Society for Peritoneal Dialysis (ISPD) published guidelines for the provision of goal-directed, high quality peritoneal dialysis that specifically included recommendations for adaptation in low and middle income countries.[26] Similar guidelines should be developed for HD and should cover areas such as incremental HD, dialyzer reuse, machine sterilization, minimum reported quality indicators and infection control procedures.

Another important component of care for kidney failure patients is vascular access for HD initiation. Despite substantial evidence that the initiation of HD using a central venous catheter is associated with a higher risk of morbidity and mortality,[27] only 5% of countries in the present study reported that more than 75% of patients initiate HD using permanent vascular access . Timely provision of dialysis access education could potentially improve this statistic, as patient dialysis knowledge has been shown to be associated with higher use of permanent dialysis access.[28]

The present study is one of the largest global health surveys ever conducted, with data from 160 countries covering more than 98% of the world's population. A validated framework was used to assess chronic diseases, with broad coverage across all regions and country income levels. Data accuracy was assured by collecting responses from multiple sources within a country (leading clinicians, policymakers and consumer representatives) and verifying the provided information with regional and national stakeholders. Rather than just considering the incidence, prevalence and availability of HD, the survey also included

items designed to evaluate HD center density, accessibility and affordability, and quality monitoring and reporting. These strengths should be balanced against the study's limitations, including the fact that it was a cross-sectional study based on an online survey that relied largely on respondents' knowledge. The possibility of response bias, including social desirability bias, could not be excluded. The findings from this study required further validation with more participants from each country and consideration of probabilistic sampling. In addition, the granularity of data collection was limited in order to obtain a high response rate, but resulted in a restricted ability to provide more in-depth explanations for the observed outcomes from each country. Finally, the study presented and compared the accessibility of dialysis across countries in percentages, which should be interpreted with cautions given the widely varying population sizes (and therefore widely varying absolute numbers of people affected per percentage point) between different countries.

In summary, this global survey of chronic HD care revealed considerable within- and between-country variation in HD use, availability, accessibility, affordability, quality monitoring and reporting. These disparities were more marked in low and lower-middle-income countries, particularly in Africa and South Asia. The findings from this study carry significant implications for policymakers and advocacy groups with respect to delivering equitable, cost-effective, high-quality HD to patients around the globe in the future.

**Supplementary materials**

**Table S1.** Response rate for each country (expressed as the number of respondents divided by the number of contracted people in each country)

**Supplementary Appendix 1**: Global Kidney Health Atlas topical survey - questionnaires specific to hemodialysis service

**Figure S1**. Availability of adequate frequency hemodialysis (defined as at least 3-4 four hours per session thrice weekly) in 154 countries, by World Bank income group and ISN region

**Figure S2**. Availability of home-based hemodialysis services in 154 countries, by World Bank income group and ISN region

**Figure S3.** Funding for vascular access for hemodialysis (central venous catheters) in 159 countries, by World Bank income group and ISN region

**Figure S4**. Funding for vascular access for hemodialysis (fistula or graft) in 159 countries, by World Bank income group or ISN region.

**Figure S5.** Hemodialysis quality indicators measured and reported in 144 countries, classified by World Bank income group

**Figure S6**. Types of vascular access for hemodialysis and availability of dialysis access education in 154 countries, by World Bank income group

**Article Information**

Authors' contributions: Research idea and study design: DWJ, AKB, HH, AL; data acquisition: AKB, ML, MAO, FY, GEA, EB-F, MBG, SND, MG, PH, VJ, KKZ, PGK, SK, CPK, VAL, BN, DO, SO, JP, HUR, ER, EJS, SS, LS, IT, VT, KT, RTK, AY-MW, C-WY, AZ, M-hZ, KJJ, FC, VP, KKJ, IGO, MT, DCH, DWJ; data analysis/interpretation: HH, AKB, MAO, FY, DWJ; statistical analysis: HH, FY, MAO; supervision and mentorship: AKB, AL, ML, MAO, FY, GEA, EB-F, MBG, SND, MG, PH, VJ, KKZ, PGK, SK, CPK, VAL, BN, DO, SO, JP, HUR, ER, EJS, SS, LS, IT, VT, KT, RTK, AY-MW, C-WY, AZ, M-hZ, KJJ, FC, VP, KKJ, IGO, MT, DCH, DWJ. Each author contributed important intellectual content during manuscript drafting or revision and agrees to be personally accountable for the individual's own contributions and to ensure that questions pertaining to the accuracy or integrity of any portion of the work, even one in which the author was not directly involved, are appropriately investigated and resolved, including with documentation in the literature if appropriate.

Support: This study was supported by the International Society of Nephrology as part of Global Kidney Health Atlas project (grant RES0033080 to the University of Alberta).

Financial Disclosure: The ISN provided administrative support for the design and implementation of the study and data collection activities. The authors were responsible for data management, analysis and interpretation, as well as manuscript preparation, review and approval, and the decision to submit the manuscript for publication. DWJ has received consultancy fees, research grants, speaker's honoraria and travel sponsorships for Baxter Healthcare and Fresenius Medical Care. He is supported by a National Health and Medical Research Council Practitioner Fellowship. HH has received consultancy fees and travel sponsorships from AWAK technology, speaker's honoraria and travel sponsorships from Baxter Healthcare and research grants from Johnson & Johnson Company and Singhealth. AKB has received consultancy fees from Janssen and grant from Canadian Institute of Health Research. AYMW has received speaker honoraria and Travel grants from Sanofi Renal and Fresinius Kabi and research grant from Sanofi Renal and Baxter Healthcare. VP has received personal fees for advisory boards or scientific presentations from Janssen, Merck, Retrophin, and Servier, fees paid to his institution for advisory boards, steering committee roles, or scientific presentations from Abbvie, Astellas, Astra Zeneca, Baxter, Boehringer Ingelheim, Dimerix, Durect, Gilead, Janssen, Novartis, Novo Nordisk, Pfizer, Pharmalink, Relypsa, Sanofi, and Tricida and grants from the National Health and Medical Research Council of Australia, Janssen, and Pfizer and senior research fellowship from National Health and Medical Research Council of Australia. CPK has received personal fees from Amgen, Sanofi-aventis, Fresenius Medical Care, Keryx,, Bayer, Abbott, Abbvie, Dr. Schar, GSK, Astra Zeneca, Takeda, outside the submitted work and grant from Shire. KKZ reports personal fees from Abbott, Abbvie, Alexion, Amag Pharma, Amgen, AstraZeneca, Aveo, Baxter, Chugai, Dr Shaer, Fresenius Medical Care, Genentech, Haymarket, Hospira, Kabi, Keryx, Novartis, PCORI, Pfizer, Relypsa, Resverlogix, Sandoz, Sanofi, Vifor, ZS-Pharma, and UpToDate, free access to national data and biobank specimens from DaVita, and grants and personal fees from Shire and the National Institutes of Health; PH reports grants from Chiesi Pharmaceuticals; PGK has received honorarium from Bayer, Astra Zeneca; VJ has received consultancy fees from NephroPlus; VT has received consulting fees from Amgen, Calliditas, FMC, Retrophin; BN reports travel expenses from Janssen; JP reports grants and personal fees from Baxter Healthcare, Fresenius Medical

Care, and Davita Healthcare partner; RTK reports personal fees from Baxter; KJJ reports personal fees from Fresenius Medical Care; All other authors have no conflict of interest to declare.

Acknowledgements: We thank Sandrine Damster,BSci, Research Project Manager at the ISN, and Alberta Kidney Disease Network (AKDN) staff (G. Houston, BA; S. Szigety, RN, BSci; S. Tiv, BSci) for helping to organize and conduct the survey and providing project management support. The prominent role by Jo-Ann Donner (Awards, Endorsements, ISN-ANIO Programs Coordinator) in the manuscript management and submission process is well acknowledged. We thank the ISN staff (Charu Malik, Claire Van Der Linden, Luisa Strani and, Luca Segantini) for their support. We thank the GKHA steering committee, executive committee of the ISN, ISN regional leadership as well as the leaders of the ISN Affiliate Societies at the regional and country levels for their help, particularly with identification of survey respondents and data acquisition, which ensured the success of this initiative. None of the persons acknowledged received compensation for their role in the study

**References**

1. Prasad N, Jha V. Hemodialysis in Asia. *Kidney Dis (Basel, Switzerland)*. 2015;1(3):165-177. doi:10.1159/000441816

2. Liyanage T, Ninomiya T, Jha V, et al. Worldwide access to treatment for end-stage kidney disease: a systematic review. *www.thelancet.com*. 2015;385. doi:10.1016/S0140-6736(14)61601-9

3. Xie Y, Bowe B, Mokdad AH, et al. Analysis of the Global Burden of Disease study highlights the global, regional, and national trends of chronic kidney disease epidemiology from 1990 to 2016. *Kidney Int*. 2018;94(3):567-581. doi:10.1016/j.kint.2018.04.011

4. U.S. Renal Data System, USRDS 2018 Annual Data Report: Atlas of End-Stage Renal Disease in the United States. https://www.usrds.org/. Accessed August 10, 2019.

5. Bello AK, Johnson DW, Feehally J, et al. Global Kidney Health Atlas (GKHA): design and

methods. *Kidney Int Suppl*. 2017;7(2):145-153. doi:10.1016/j.kisu.2017.08.001

6. Htay H, Alrukhaimi M, Ashuntantang GE, et al. Global access of patients with kidney disease to health technologies and medications: findings from the Global Kidney Health Atlas project. *Kidney Int Suppl*. 2018;8(2):64-73. doi:10.1016/j.kisu.2017.10.010

7. Global Kidney Health Atlas. https://www2.theisn.org/GKHA. Accessed July 22, 2019.

8. Bello AK, Levin A, Lunney M, et al. Status of care for end stage kidney disease in countries and regions worldwide: international cross sectional survey. *BMJ*. 2019;367:l5873. doi:10.1136/bmj.l5873

9. Eysenbach G. Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES). *J Med Internet Res*. 2004;6(3):e34. doi:10.2196/jmir.6.3.e34

10. Jha V, Modi GK. Getting to know the enemy better-the global burden of chronic kidney disease. *Kidney Int*. 2018;94(3):462-464. doi:10.1016/j.kint.2018.05.009

11. Lübbeke A, Carr AJ, Hoffmeyer P. Registry stakeholders. *EFORT Open Rev*. 2019;4(6):330-336. doi:10.1302/2058-5241.4.180077

12. Hoque DME, Kumari V, Ruseckaite R, Romero L, Evans SM. Impact of clinical registries on quality of patient care and health outcomes: protocol for a systematic review. *BMJ Open*. 2016;6(4):e010654. doi:10.1136/bmjopen-2015-010654

13. See EJ, Alrukhaimi M, Ashuntantang GE, et al. Global coverage of health information systems for kidney disease: availability, challenges, and opportunities for development. *Kidney Int Suppl*. 2018;8(2):74-81. doi:10.1016/J.KISU.2017.10.011

14. SHARing Expertise to support the set-up of Renal Registries (SharE-RR). https://www.theisn.org/advocacy/share-rr. Accessed July 28, 2019.

15. Swanepoel CR, Wearne N, Okpechi IG. Nephrology in Africa—not yet uhuru. *Nat Rev Nephrol*. 2013;9(10):610-622. doi:10.1038/nrneph.2013.168

16. Kumar V, Jha V. End-stage renal disease care in South Asia: demographics, economics, and opportunities. *Clin Nephrol*. 2016;86(S1):23-26. doi:10.5414/CNP86S103

17. Crews DC, Bello AK, Saadi G, for the World Kidney Day Steering Committee. Burden, Access, and Disparities in Kidney Disease. *Kidney Dis*. 2019;5(2):126-134. doi:10.1159/000494897

18. Shaikh M, Woodward M, John O, et al. Utilization, costs, and outcomes for patients receiving publicly funded hemodialysis in India. *Kidney Int*. 2018;94(3):440-445. doi:10.1016/j.kint.2018.03.028

19. Harris DCH, Davies SJ, Finkelstein FO, et al. Increasing access to integrated ESKD care as part of universal health coverage. *Kidney Int*. 2019;95(4S):S1-S33. doi:10.1016/j.kint.2018.12.005

20. Teerawattananon Y, Mugford M, Tangcharoensathien V. Economic Evaluation of Palliative Management versus Peritoneal Dialysis and Hemodialysis for End-Stage Renal Disease: Evidence for Coverage Decisions in Thailand. *Value Heal*. 2007;10(1):61-72. doi:10.1111/j.1524-4733.2006.00145.x

21. Afiatin, Khoe LC, Kristin E, et al. Economic evaluation of policy options for dialysis in end-stage renal disease patients under the universal health coverage in Indonesia. *PLoS One*. 2017;12(5):e0177436. doi:10.1371/journal.pone.0177436

22. Diamantidis CJ, Becker S. Health information technology (IT) to improve the care of patients with chronic kidney disease (CKD). *BMC Nephrol*. 2014;15:7. doi:10.1186/1471-2369-15-7

23. ISO 23500-5:2019 - Preparation and quality management of fluids for haemodialysis and related therapies -- Part 5: Quality of dialysis fluid for haemodialysis and related therapies.

https://www.iso.org/standard/67614.html. Accessed August 10, 2019.

24. Mactier R, Morgan I, Boyle G, Infirmary GR, Croft D, Thompson C. *Guideline on Water Treatment Systems, Dialysis Water and Dialysis Fluid Quality for Haemodialysis and Related Therapies Clinical Practice Guideline*.

25. Fervers B, Burgers JS, Voellinger R, et al. Guideline adaptation: an approach to enhance efficiency in guideline development and improve utilisation. *BMJ Qual Saf*. 2011;20(3):228-236. doi:10.1136/bmjqs.2010.043257

26. Brown EA, Blake PG, Boudville N, et al. International Society for Peritoneal Dialysis practice recommendations: Prescribing high-quality goal-directed peritoneal dialysis. *Perit Dial Int J Int Soc Perit Dial*. January 2020:089686081989536. doi:10.1177/0896860819895364

27. Perl J, Wald R, McFarlane P, et al. Hemodialysis Vascular Access Modifies the Association between Dialysis Modality and Survival. *J Am Soc Nephrol*. 2011;22(6):1113-1121. doi:10.1681/ASN.2010111155

28. Cavanaugh KL, Wingard RL, Hakim RM, Elasy TA, Alp Ikizler T. Patient Dialysis Knowledge Is Associated with Permanent Arteriovenous Access Use in Chronic Hemodialysis. *Clin J Am Soc Nephrol*. 2009;4:950-956. doi:10.2215/CJN.04580908

Table 1. Summary table of use of hemodialysis and total treated kidney failure patients classified by World Bank income groups, ISN regions and globally.

| Variables | | Total treated kidney failure patients | | Total treated new kidney failure | | HD use | | HD use in new kidney failure |
|---|---|---|---|---|---|---|---|---|
| | (n) | (pmp) | (n) | (pmp) | (n) | (pmp) | (n) | (pmp) |
| Globally | 91 | 759.0(433.0-1048.0) | 79 | 141.0 (103.1-200.2) | 126 | 298.4(80.5-599.4) | 26 | 108.8 (81.5-150.1) |
| ***ISN regions*** | | | | | | | | |
| Africa | 5 | 541.0(181.0-624.0) | 4 | 100.0(39.0-151.5) | 30 | 13.8(4.4-103.0) | 0 | Not reported |
| Eastern & Central Europe | 15 | 759.0 (620.0-1008.3) | 16 | 144.5(108.5-178.5) | 16 | 477.6(280.5-571.4) | 6 | 105.4(81.5-122.5) |
| Latin America | 20 | 558.1(313.3-868.5) | 18 | 167.5(94.8-208.3) | 20 | 310.6(191.1-552.3) | 0 | Not reported |
| Middle East | 8 | 636.0(295.4-728.5) | 6 | 132(120.0-145.0) | 10 | 256.7(184.1-409.5) | 0 | Not reported |
| NIS and Russia | 5 | 289.0(211.0-310.0) | 4 | 60.5(44.0-132.5) | 4 | 137.6(89.8-178.2) | 0 | Not reported |
| North America & the Caribbean | 7 | 682.5(334.6-1346.4) | 2 | 289.1(200.2-378.0) | 11 | 630.1(321.0-1399.1) | 2 | 243.4(150.1-336.7) |
| North & East Asia | 3 | 2599.0(1816.0-3392.0) | 3 | 311.0(296.0-493.0) | 4 | 1661.4(646.2-2127.6) | 1 | 94.4(94.4-94.4) * |
| Oceania & South East Asia | 8 | 1170.0(644.5-1594.0) | 8 | 215.5(127-339.5) | 8 | 553.7(239.9-896.8) | 4 | 139.8(110.6-176.5) |
| South Asia | 1 | 117(117.0-117.0) * | 1 | 51.0(51.0-51.0) * | 4 | 26.2(14.1-73.2) | 0 | Not reported |
| Western Europe | 19 | 979.0(885.0-1234.0) | 17 | 128.0(106.0-165.0) | 19 | 473.3(319.6-662.8) | 13 | 82.1(74.6-116.1) |
| ***World Bank income groups*** | | | | | | | | |
| Low | 1 | 4.4(4.4-4.4) * | 0 | Not reported | 11 | 3.9(0.9-8.3) | 0 | Not reported |
| Lower-middle | 12 | 321.0 (227.4 -567.9) | 12 | 129.9(53.5-174.4) | 27 | 67.9(15.4-162.0) | 0 | Not reported |
| Upper-middle | 27 | 550.2 (289.0-780.0) | 22 | 126.0(80.0-194.0) | 34 | 334.1(178.8-531.2) | 7 | 122.5(94.4-173.5) |
| High | 51 | 966.0(759.0-1269.0) | 45 | 149.0(119.0-207.5) | 54 | 513.7(333.4-738.8) | 19 | 101.5(74.6-140.8) |

HD = hemodialysis; ISN = International Society of Nephrology; NIS: Newly Independent States; pmp: per million population; n= number of countries
*single country report
Data are presented in median (interquartile range)

Table 2. Hemodialysis center density, availability of hemodialysis services in a country, accessibility of dialysis at the onset of kidney failure in 154 countries, by World Bank income groups, ISN regions and globally.

| Category | (n) | HD center density (pmp) | (n) | Availability (proportion of hospitals or clinics providing HD service in a country) | | Accessibility (Proportion of kidney failure patients receiving dialysis at the onset of kidney failure) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ≥ 50% | < 50% | 0% | 1–10% | 11–25% | 26–50% | > 50% |
| Overall | 154 | 4.5 (1.2-9.9) | 154 | 129 (84) | 25 (16) | 4 (3) | 26 (17) | 6 (4) | 10 (6) | 108 (70) |
| *ISN regions* | | | | | | | | | | |
| Africa | 39 | 0.5 (0.2-2.2) | 41 | 24 (59) | 17 (41) | 1 (2) | 20 (49) | 2 (5) | 4 (10) | 14 (34) |
| Eastern & Central Europe | 19 | 9.2 (6.5 -10.8) | 19 | 19 (100) | 0 (0) | 1 (5) | 0 (0) | 0 (0) | 0 (0) | 18 (95) |
| Latin America | 18 | 4.6 (2.9-10.9) | 18 | 16 (89) | 2 (11) | 0 (0) | 1 (6) | 0 (0) | 0 (0) | 17 (94) |
| Middle East | 11 | 3.8 (2.1-5.7) | 11 | 11 (100) | 0 (0) | 1 (9) | 1 (9) | 0 (0) | 0 (0) | 9 (82) |
| NIS & Russia | 7 | 3.7 (2.2-5.5) | 7 | 7 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 1 (14) | 6 (86) |
| North America & the Caribbean | 9 | 18.1 (10.4-19.6) | 9 | 7 (78) | 2 (22) | 0 (0) | 2 (22) | 0 (0) | 0 (0) | 7 (78) |
| North & East Asia | 7 | 14.2 (1.8-34.8) | 7 | 7 (100) | 0 (0) | 0 (0) | 0 (0) | 1 (14) | 0 (0) | 6 (86) |
| Oceania & South East Asia | 15 | 5.7 (1.5-14.4) | 15 | 13 (87) | 2 (13) | 0 (0) | 1 (7) | 2 (13) | 2 (13) | 10 (67) |
| South Asia | 7 | 1.4 (0.6-1.7) | 7 | 5 (71) | 2 (29) | 1 (14) | 1 (14) | 2 (29) | 2 (29) | 1 (14) |
| Western Europe | 21 | 6.9 (4.5-9.9) | 20 | 20 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 20 (100) |
| *World Bank income groups* | | | | | | | | | | |
| Low-income | 20 | 0.2 (0.2-0.4) | 22 | 7 (32) | 15 (68) | 1 (5) | 16 (73) | 1 (5) | 3 (13) | 1 (5) |
| Lower-middle-income | 36 | 1.6 (0.8-3.8) | 35 | 30 (86) | 5 (14) | 2 (6) | 4 (11) | 4 (11) | 5 (14) | 20 (57) |
| Upper-middle-income | 41 | 5.3 (3.5-9.9) | 41 | 38 (93) | 3 (7) | 1 (3) | 4 (10) | 1 (2) | 2 (5) | 33 (80) |
| High-income | 57 | 9.5 (4.7-14.2) | 56 | 54 (96) | 2 (4) | 0 (0) | 2 (4) | 0 (0) | 0 (0) | 54 (96) |

Data are presented in median (interquartile range) or frequencies (percentages)

HD: hemodialysis; ISN: International Society of Nephrology; NIS: Newly Independent States; pmp: per million population; n= number of countries

**Table 3.** Annual maintenance hemodialysis cost and co-payments for hemodialysis patients in 154 countries, expressed as a proportion of treatment cost directly paid by patients, by World Bank income groups, ISN regions and globally.

| Category | Annual cost of chronic HD*, median (interquartile range) | National average co-payment proportions by patients for HD service | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (n) | 0% | 1–25% | 26–50% | 51–75% | >75% | 100% | Unknown |
| Overall | 22616.8 (14882-49690.3) | 154 | 41 (27) | 59 (38) | 12 (8) | 8 (5) | 11 (7) | 12 (8) | 11 (7) |
| *ISN regions* | | | | | | | | |
| Africa | 12059.7 (5980.0-23605.6) | 41 | 9 (22) | 13 (31) | 2 (5) | 0 (0) | 6 (15) | 5 (12) | 6 (15) |
| Eastern & Central Europe | 20077.0 (16133.0-27290.1) | 19 | 6 (32) | 8 (42) | 0 (0) | 0 (0) | 0 (0) | 4 (21) | 1 (5) |
| Latin America | 19712.3 (16147.7-39695.1) | 18 | 5 (28) | 6 (33) | 3 (16) | 1 (6) | 1 (6) | 0 (0) | 2 (11) |
| Middle East | 19489.1 (15860.0-50739.5) | 11 | 2 (18) | 7 (64) | 0 (0) | 1 (9) | 0 (0) | 0 (0) | 1 (9) |
| NIS & Russia | 5876.0 (5070.0-14882.0) | 7 | 3 (43) | 2 (29) | 1 (14) | 1 (14) | 0 (0) | 0 (0) | 0 (0) |
| North American & the Caribbean | 73788.5 (25374.0-88395.1) | 9 | 2 (22) | 2 (22) | 1 (11) | 2 (22) | 0 (0) | 1 (11) | 1 (11) |
| North and East Asia | 28845.5 (21214.4-43953.9) | 7 | 0 (0) | 7 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Oceania & South East Asia | 20204.7 (8759.7-28558.5) | 15 | 1 (7) | 5 (33) | 4 (27) | 0 (0) | 3 (20) | 2 (13) | 0 (0) |
| South Asia | 5201.9 (4873.3-9849.5) | 7 | 2 (29) | 0 (0) | 1 (14) | 3 (43) | 1 (14) | 0 (0) | 0 (0) |
| Western Europe | 60037.0 (50846.9-76642.1) | 20 | 11 (55) | 9 (45) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| *World Bank income groups* | | | | | | | | |
| Low income | 20463.2 (7603.5-36174.0) | 22 | 5 (23) | 2 (9) | 2 (9) | 1 (5) | 5 (23) | 3 (14) | 4 (18) |
| Lower-middle income | 9994.7 (5579.0-19023.8) | 35 | 6 (17) | 10 (29) | 5 (14) | 3 (9) | 4 (11) | 4 (11) | 3 (9) |
| Upper-middle income | 17118.7 (13829.6-25797.2) | 41 | 8 (20) | 20 (49) | 3 (7) | 3 (7) | 2 (5) | 3 (7) | 2 (5) |
| High income | 49720.5 (25374.0-60498.0) | 56 | 22 (39) | 27 (48) | 2 (4) | 1 (2) | 0 (0) | 2 (4) | 2 (4) |

HD: hemodialysis; ISN: International Society of Nephrology; NIS: Newly Independent States; pmp: n= number of countries; the denominator used in the calculation of proportion is the number of countries that had HD available. *Data from 97 countries and presented in USD.

**Figure Legend:**

**Figure 1.** Hemodialysis quality indicators monitored and reported in 144 countries.

(None: 0%; Few: 1-10%; Some: 11-50%; Most: 51-75%; Almost all: >75%).