

# Workforce capacity for the care of patients with kidney failure across world countries and regions

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## ABSTRACT

**Introduction** An effective workforce is essential for optimal care of all forms of chronic diseases. The objective of this study was to assess workforce capacity for kidney failure (KF) care across world countries and regions.

**Methods** Data were collected from published online sources and a survey was administered online to key stakeholders. All country-level data were analysed by International Society of Nephrology region and World Bank income classification.

**Results** The general healthcare workforce varies by income level: high-income countries have more healthcare workers per 10 000 population (physicians: 30.3; nursing personnel: 79.2; pharmacists: 7.2; surgeons: 3.5) than low-income countries (physicians: 0.9; nursing personnel: 5.0; pharmacists: 0.1; surgeons: 0.03). A total of 160 countries responded to survey questions pertaining to the workforce for the management of patients with KF. The physicians primarily responsible for providing care to patients with KF are nephrologists in 92% of countries. Global nephrologist density is 10.0 per million population (pmp) and nephrology trainee density is 1.4 pmp. High-income countries reported the highest densities of nephrologists and nephrology trainees (23.2 pmp and 3.8 pmp, respectively), whereas low-income countries reported the lowest densities (0.2 pmp and 0.1 pmp, respectively). Low-income countries were most likely to report shortages of all types of healthcare providers, including nephrologists, surgeons, radiologists and nurses.

**Conclusions** Results from this global survey demonstrate critical shortages in workforce capacity to care for patients with KF across world countries and regions. National and international policies will be required to build a workforce capacity that can effectively address the growing burden of KF and deliver optimal care.

## INTRODUCTION

The global burden of chronic kidney disease (CKD) continues to rise, with a current prevalence estimated at 13.4%.<sup>1–3</sup> Patients with kidney disease are notably complex, with recent studies showing that nephrologists

## Key questions

### What is already known?

- Many countries in developing economies, especially in Latin America, Africa and parts of Asia, have a scarcity of all cadres of healthcare workers.
- There is a scarcity of nephrologists in many countries in the world; however, the extent of this scarcity has not been previously fully quantified.

### What are the new findings?

- Our data show a varying scarcity of workforce in nephrology across all sectors (physicians, surgeons, nurses, technicians) in different parts of the world.
- There is a very low nephrology trainee density in mainly developing world regions which further impacts on density of nephrologists.

### What do the new findings imply?

- A demonstration of critical shortages in workforce capacity to care for patients with kidney failure across world countries and regions.
- The need for national and international policies to build a workforce capacity that can effectively address the growing burden of kidney failure and deliver optimal care.

rank highest compared with all other general and medical subspecialists with regard to patient complexity.<sup>4</sup> The presence of CKD indicates a higher risk of adverse events for patients with diabetes, hypertension and cardiovascular disease.<sup>2 5 6</sup> Furthermore, CKD is associated with increasing healthcare costs.<sup>5</sup>

The delivery of comprehensive kidney disease care, including risk factor modification, kidney replacement therapy (dialysis and kidney transplantation), delivery and transplant services, requires a large workforce with adequate geographical coverage to meet the growing healthcare needs of patients with CKD.<sup>2 5 7 8</sup> However, recent surveys from the

first iteration of the International Society of Nephrology Global Kidney Health Atlas (ISN-GKHA) revealed a global shortage of nephrologists and other healthcare providers essential for kidney disease care, with a much greater disparity reported in lower income countries.<sup>9</sup> The nephrology workforce is predicted to further decrease in size and capacity over the next decade, which will further exacerbate current demand for kidney disease care.<sup>10</sup>

The second iteration of the ISN-GKHA was a multinational, cross-sectional survey to assess international variability in the capacity for kidney failure care. One aim of the survey was to assess the current global workforce capacity for kidney failure care and identify areas with healthcare provider shortages. This is the first study to provide data regarding the availability of not only nephrologists and nephrology trainees, but also other healthcare professionals involved in kidney failure care worldwide.

## METHODS

The ISN-GKHA is a project targeted at monitoring and evaluating global capacity for kidney care that combines desk research with an international survey of key stakeholders. The full methodology for the second iteration of the ISN-GKHA has been published elsewhere,<sup>11–13</sup> as have details about the development and validation of the survey.<sup>13 14</sup> Two iterations of the survey were conducted in 2016 and 2018.<sup>11 14</sup> Here, we report responses to items from the second survey conducted in 2018 related to workforce capacity for kidney failure care.

### Desk research

Desk research efforts involved a broad literature review in April 2020 of national health systems associated with health workforce to determine the density of physicians, surgeons, nursing personnel and pharmacists in individual countries. Data sources included The World Factbook from the Central Intelligence Agency (CIA)<sup>15</sup> and the Global Health Observatory Data Repository from the WHO.<sup>16–18</sup>

### Survey data

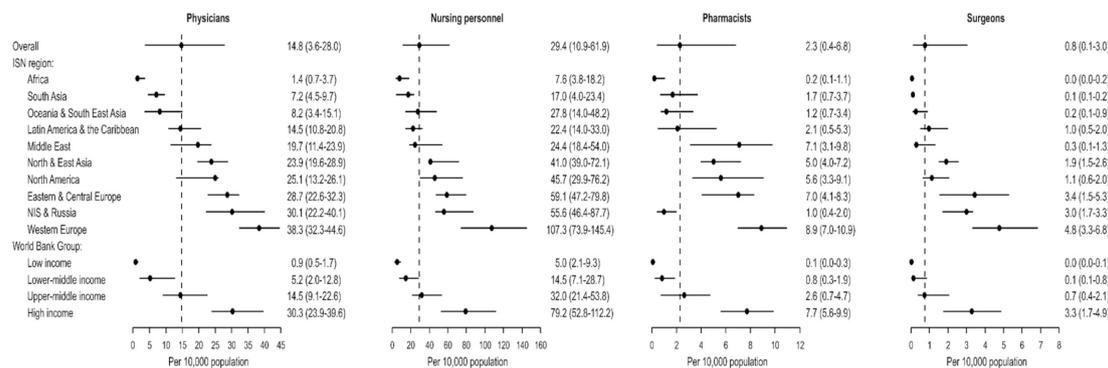
The ISN-GKHA questionnaire was designed to assess national and regional profiles for readiness, capacity and responsiveness to kidney failure, including questions about the availability of nephrologists, nephrology trainees and other healthcare providers essential for kidney failure care delivery. A non-probability, purposive sampling approach was used to identify survey respondents. National and regional nephrology leaders affiliated with the ISN identified key stakeholders, including representatives of national nephrology societies, policymakers, patient organisations, foundations and other advocacy groups. Key stakeholders were sent invitations to participate in the survey through a link to the survey's online portal, an electronic questionnaire via REDCap Cloud ([www.redcapcloud.com](http://www.redcapcloud.com)). Three key opinion leaders from each country were invited to complete the survey: a

nephrology society leader, a leader of a consumer representative organisation and a policymaker.

The survey was conducted from July to September 2018; during this period, intensive follow-up was conducted by email and phone with ISN regional and national leaders to ensure complete and timely responses. Regional and national project leaders were identified through international contacts, collaborators, ISN leaders and the ISN's 10 Regional Boards (Africa, Eastern and Central Europe, Latin America, the Middle East, North America and the Caribbean, North and East Asia, Oceania and Southeast Asia, the Newly Independent States (NIS) and Russia, South Asia, and Western Europe). The ISN regions are based on geographical proximity of countries that enable the ISN to effectively engage in advocacy and implement training and educational programmes in those areas. For instance, although Mexico is part of North America, it is part of the ISN's Latin American region (<https://www.theisn.org/about-isn/regions>). Each project leader was responsible for: (a) organising and following up on responses from each region and country; (b) serving as a liaison between the steering committee, the ISN and regional/national stakeholders; (c) providing access to additional data sources and contacts for surveys; (d) identifying or serving as an opinion leader on the project for the region/country; and (e) identifying or serving as a resource person to vet and review regional/national data.

### Data handling and statistical analysis

For the survey data, after responses to the French and Spanish versions of the survey were translated into English by certified translators, data were extracted from all individual questionnaires and cleaned using Microsoft Excel. Responses were merged into a single file to create the global database. ISN regional leaders were consulted to ensure that the collected data were consistent with their understandings and were of high quality. Any major inconsistencies in responses at the country level were addressed with the stakeholders involved with the survey and clarified by ISN regional leaders when necessary. Using country as the unit of analysis, we imported the data into Stata V.15 software (Stata Corporation, 2017) and analysed it using a well-validated framework developed by the WHO: Assessing National Capacity for the Prevention and Control of Non-Communicable Diseases. We validated our results by triangulating the findings with academic research and grey literature, including government reports. The responses for survey items were summarised using descriptive statistics to report absolute counts and percentages. The density of each category of healthcare provider, including physicians, nursing personnel, surgeons, pharmacists, nephrologists and nephrology trainees, was calculated as the total number of healthcare provider divided by the country's total population. Country population was obtained from the World Factbook of the CIA.<sup>15</sup> Data were reported using



**Figure 1** Density of healthcare providers (per 10 000 population) (regional data for physicians are presented in ascending order (median and IQR)). Density of physicians, nursing personnel, pharmacists and surgeons, calculated by taking the total number of physicians, nursing personnel, pharmacists and surgeons reported in each country, respectively, and dividing it by each country's population, grouped by ISN region and World Bank income group. Data from: The World Factbook from the Central Intelligence Agency<sup>15</sup> and the Global Health Observatory Data Repository from the WHO.<sup>16–18</sup> ISN, International Society of Nephrology; NIS, Newly Independent States.

median (IQR) and results were stratified by ISN region and World Bank income group.

### Patient and public involvement

Patients were not involved in our study. Members of the global nephrology community participated in this survey.

## RESULTS

### Availability (regional densities) of healthcare providers

Data from 196 countries were evaluated to assess the regional densities of physicians, nursing personnel, pharmacists and surgeons. All the data in this section are presented as number per 10 000 population. The global median density of physicians was 14.8 (IQR 3.6–27.9), with the highest densities in Western Europe (38.3), the NIS and Russia (30.1), Eastern and Central Europe (28.7), North America (25.1), and North and East Asia (23.9). Densities of physicians in the Middle East (19.7) and Latin America and the Caribbean (14.5) were close to the global median. The lowest densities of physicians were in Oceania and Southeast Asia (8.2), South Asia (7.2) and Africa (1.4). A direct relationship existed between physician density and World Bank income group (high income: 30.3; upper-middle income: 14.5; lower-middle income: 5.2; low-income: 0.9) (figure 1). Nursing personnel had the highest median global density compared with other healthcare professionals (29.4, IQR 10.9–60.9). However, there was significant variability in the density of nursing personnel across ISN regions, with the highest density in Western Europe (107.9) and the lowest density in Africa (6.7) (figure 1). The global median density of pharmacists was 2.3 (IQR 0.4–6.8). High-income countries had the highest density of pharmacists (7.2), followed by upper-middle-income countries (2.8), lower-middle-income countries (0.8) and low-income countries (0.1) (figure 1). Among all healthcare professionals, the global density of surgeons was the lowest, at 0.8 (IQR 0.1–3.0) (figure 1).

### Current density of nephrologists across countries and regions

Representatives from 160 countries (88%) representing 98% of the world's population responded to survey questions about nephrologist density (online supplemental table S1). Overall, the global median number of nephrologists per million population (pmp) was 9.9 (IQR 1.2–22.7). The data revealed significant regional variability in the density of nephrologists (table 1). The regions with the highest nephrologist densities were Western Europe (24.4 pmp) and Eastern and Central Europe (25.6 pmp), followed by North and East Asia (19.5 pmp), North America (18.1 pmp), and the NIS and Russia (14.4 pmp). Nephrologist density was close to the global median in two regions (Latin America and the Caribbean: 9.8 pmp; the Middle East: 8.1 pmp), and below the global median in three regions (Oceania and Southeast Asia: 5.7 pmp; South Asia: 1.2 pmp; Africa: 0.6 pmp). Nephrologist density was directly associated with World Bank income group and varied widely, ranging from 23.2 pmp in high-income countries to 10.8 pmp in upper-middle, 1.6 in lower-middle and 0.2 pmp in low-income countries (table 1).

### Current density of nephrology trainees across countries and regions

Representatives from 144 countries (79%) responded to survey questions regarding nephrology trainee density. The global median density for nephrology trainees was 1.4 pmp (IQR 0.4–3.7). Relative to the density of nephrologists, the data showed less regional variability in the density of nephrology trainees, which ranges from 5.7 pmp in Western Europe to 0.0 pmp in North America, where the absolute number of trainees was 637 (table 1). Of the eight countries in North America, five reported that they currently had no nephrology trainees. Three countries, Canada, the USA, and St. Kitts and Nevis, reported having nephrology trainees. The density of nephrology trainees was lower than the global median in

**Table 1** Global distribution of the nephrology workforce, per million population (pmp)

Category	Nephrologist density			Nephrology trainee density		
	Total no of respondent countries	Median	IQR	Total no of respondent countries	Median	IQR
Overall	152	9.95	(1.23–22.72)	144	1.42	(0.35–3.70)
ISN region						
Africa	39	0.62	(0.24–1.56)	35	0.36	(0.06–0.92)
Eastern and Central Europe	19	25.63	(15.54–36.73)	19	3.26	(1.56–4.42)
Latin America and the Caribbean	18	9.76	(8.73–19.73)	18	1.37	(0.84–3.18)
Middle East	11	8.08	(4.97–15.87)	11	1.82	(0.72–2.86)
NIS and Russia	8	14.41	(6.62–22.33)	7	1.60	(0.46–3.25)
North America	9	18.13	(15.33–29.46)	8	0.00*	(0.00–1.74)
North and East Asia	7	19.45	(9.67–54.60)	7	3.22	(1.94–5.94)
Oceania and Southeast Asia	14	5.66	(1.08–16.59)	15	1.08	(0.30–4.51)
South Asia	7	1.15	(0.63–1.39)	6	0.29	(0.15–0.62)
Western Europe	20	24.36	(18.07–29.91)	18	5.80	(3.73–8.03)
World Bank income level						
Low	21	0.24	(0.17–0.48)	17	0.11	(0.00–0.48)
Lower-middle	35	1.58	(0.88–5.67)	36	0.57	(0.21–1.60)
Upper-middle	40	10.81	(5.08–17.03)	37	1.19	(0.77–2.60)
High	56	23.15	(16.68–30.91)	54	3.83	(1.81–7.30)

Density of nephrologists and nephrology trainees calculated by taking the total number of nephrologists or nephrology trainees provided by each country and dividing it by each country's population, grouped by ISN region and World Bank income group.

\*Although the median number is 0 for this region, the average number of nephrology trainees is 2.8 pmp.

ISN, International Society of Nephrology; NIS, Newly Independent States.

Oceania and Southeast Asia (1.1 pmp), Africa (0.4 pmp), South Asia (0.3 pmp) and North America (2.8 pmp).

### Survey response rate and primary responsibility for kidney failure care

Among the 182 countries invited to participate in the 2018 survey, representatives responded from 160 (88%) countries (online supplemental table S1). The data revealed significant variations across countries and regions in healthcare worker distribution, responsibilities and shortages (tables 2 and 3). Nephrologists were primarily responsible for providing care to patients with kidney failure in 92% of countries. Primary healthcare providers and nurse practitioners or nurses with specialised training were responsible for kidney failure care in 22% and 15% of countries, respectively. Multidisciplinary teams provided kidney failure healthcare in only 19% of countries, and health officers and extension workers provided kidney failure care in just 1% of countries (table 2).

### Current capacity of health professionals required for kidney failure care

In addition to the shortage of nephrologists reported by 70% of countries surveyed, more than half of countries reported shortages of other healthcare professionals essential for kidney failure care. Relative to other World

Bank income groups, a greater proportion of low-income countries reported shortages of all types of kidney failure healthcare providers (table 3). With regard to non-physician kidney failure healthcare providers, 71% of upper-middle-income countries reported a shortage of vascular access coordinators, 20% reported a shortage of laboratory technicians, and just over half reported shortages of transplant coordinators (61%), dialysis nurses (56%), dialysis technicians (54%), and counsellors and psychologists (54%) (table 3). Overall, a lower proportion of high-income countries reported shortages in the kidney failure workforce relative to countries in the other World Bank income groups. Although 44% of high-income countries reported a shortage of dialysis nurses, only 19% reported a shortage of dialysis technicians. Just over one-third of high-income countries reported shortages of vascular access coordinators (39%), and counsellors and psychologists (37%) (table 3).

### DISCUSSION

Our results confirm initial findings from the baseline survey for the GKHA regarding insufficient workforce capacity to provide kidney care.<sup>9</sup> There was significant variability in the density of the healthcare workforce for all areas of medicine among countries and income groups, with the highest densities of physicians, nursing

**Table 2** The distribution of clinical responsibility in the delivery of kidney failure care among healthcare providers, n (%)

Category	n	Nephrologists	Primary care physicians	Nurse practitioners or specialised nurses	Multidisciplinary teams	Health officers/ extension workers	Other
Overall	157	144 (92)	34 (22)	23 (15)	30 (19)	2 (1)	3 (2)
ISN region							
Africa	41	32 (78)	12 (29)	4 (10)	7 (17)	0 (0)	1 (2)
Eastern and Central Europe	19	19 (100)	4 (21)	0 (0)	1 (5)	0 (0)	0 (0)
Latin America and the Caribbean	18	18 (100)	4 (22)	3 (17)	5 (28)	0 (0)	0 (0)
Middle East	11	11 (100)	1 (9)	4 (36)	4 (36)	0 (0)	0 (0)
NIS and Russia	9	9 (100)	2 (22)	0 (0)	0 (0)	1 (11)	0 (0)
North America	9	8 (89)	2 (22)	2 (22)	3 (33)	0 (0)	0 (0)
North and East Asia	7	7 (100)	0 (0)	3 (43)	2 (29)	0 (0)	0 (0)
Oceania and Southeast Asia	15	14 (93)	5 (33)	5 (33)	5 (33)	1 (7)	1 (7)
South Asia	7	5 (71)	2 (29)	0 (0)	2 (29)	0 (0)	1 (14)
Western Europe	21	21 (100)	2 (10)	2 (10)	1 (5)	0 (0)	0 (0)
World Bank income level							
Low	22	16 (73)	9 (41)	1 (5)	2 (9)	0 (0)	1 (5)
Lower-middle	37	33 (89)	11 (30)	4 (11)	6 (16)	2 (5)	1 (3)
Upper-middle	41	39 (95)	8 (20)	6 (15)	11 (27)	0 (0)	1 (2)
High	57	56 (98)	6 (11)	12 (21)	11 (19)	0 (0)	0 (0)

Number of countries that reported the healthcare providers primarily responsible for kidney failure clinical care, grouped by ISN region and World Bank income group. Percentages calculated as the number of responding countries divided by the total number of responding countries.

ISN, International Society of Nephrology; n, number of participating countries; NIS, Newly Independent States.

personnel, pharmacists and surgeons in high-income countries, and the lowest densities in low-income countries. The density of nursing personnel was higher than the densities of physicians, surgeons, and pharmacists across countries and income groups. Most of the countries surveyed reported that nephrologists were primarily responsible for delivering kidney failure care. In terms of distribution, the density of nephrologists in high-income countries is over 60 times that in low-income countries, and the majority of low-income countries reported shortages of other key healthcare professionals involved in kidney care. For instance, the availability of pharmacists, surgeons, and nursing personnel is 70-fold, 350-fold and 16-fold higher, respectively, in high-income countries compared with low-income countries. These data highlight the need for strategies to increase the global nephrology workforce, especially in low-income countries.

In kidney failure management, an effective workforce is an essential component of optimal care delivery.<sup>19–22</sup> Several considerations should be taken into account to accurately interpret data pertaining to the nephrology workforce in diverse global settings.<sup>23–26</sup> The substantial between-country variation in the organisation of specialised nephrology care is an important factor to be

considered when interpreting our findings. For instance, in some countries, nephrologists provide care for the entire spectrum of kidney conditions from early CKD to kidney failure, whereas in other countries, nephrologists only treat patients with established kidney failure and provide more specialised care (ie, dialysis or transplant services). Task shifting, which involves training primary care providers, nurses or other professionals to provide kidney failure care with remote guidance from nephrologists and/or support from standard algorithms, may help improve capacity to deliver high-quality kidney failure care in countries with limited nephrologist availability.<sup>23 25 26</sup>

While the densities reported in our survey do not reflect factors such as burden of kidney failure, more nephrologists are needed in low-income countries. A number of factors have been cited as driving shortages in the nephrology workforce across countries and regions with significant variations across countries,<sup>21 27</sup> including an ageing workforce, declining interest in nephrology among trainees, lack of exposure to nephrology among students and residents, rising costs of medical education and specialist training, inflexible work schedules, erosion of nephrology practice scope by other specialists,

**Table 3** Shortages of healthcare providers essential for kidney failure care, n (%)

Category	Healthcare provider															
	n	Nephrologists	Transplant surgeons	Surgeons (HD access)	Surgeons (PD access)	Interventional radiologists (HD access)	Interventional radiologists (PD access)	Dietitians	Laboratory technicians	Radiologists (ultrasound)	Vascular access coordinators	Counsellors/psychologists	Transplant coordinators	Dialysis nurses	Dialysis technicians	No shortage
Overall	156	109 (70)	102 (65)	101 (65)	79 (51)	103 (66)	83 (53)	86 (55)	30 (19)	31 (20)	98 (63)	89 (57)	85 (54)	89 (57)	76 (49)	11 (7)
ISN region																
Africa	41	36 (88)	34 (83)	35 (85)	34 (83)	36 (88)	31 (76)	30 (73)	12 (29)	13 (32)	33 (80)	30 (73)	32 (78)	28 (68)	31 (76)	1 (9)
Eastern and Central Europe	19	13 (68)	10 (53)	13 (68)	6 (32)	6 (32)	5 (26)	14 (74)	0 (0)	1 (5)	10 (53)	9 (47)	7 (37)	10 (53)	4 (21)	1 (9)
Latin America and the Caribbean	18	13 (72)	13 (72)	13 (72)	9 (50)	15 (83)	11 (61)	7 (39)	1 (6)	1 (6)	12 (67)	9 (50)	10 (56)	11 (61)	7 (39)	1 (9)
Middle East	11	8 (73)	7 (64)	3 (27)	2 (18)	9 (82)	9 (82)	5 (45)	1 (9)	1 (9)	8 (73)	9 (82)	7 (64)	5 (45)	5 (45)	0 (0)
NIS and Russia	8	4 (50)	5 (63)	2 (25)	2 (25)	5 (63)	4 (50)	6 (75)	2 (25)	1 (13)	4 (50)	3 (38)	4 (50)	2 (25)	4 (50)	0 (0)
North America	9	4 (44)	7 (78)	5 (56)	3 (33)	5 (56)	4 (44)	1 (11)	0 (0)	0 (0)	3 (33)	3 (33)	4 (44)	3 (33)	4 (44)	1 (9)
North and East Asia	7	3 (43)	5 (71)	4 (57)	3 (43)	5 (71)	2 (29)	4 (57)	2 (29)	3 (43)	3 (43)	3 (43)	3 (43)	3 (43)	2 (29)	0 (0)
Oceania and Southeast Asia	15	12 (80)	10 (67)	11 (73)	10 (67)	11 (73)	9 (60)	8 (53)	6 (40)	5 (33)	12 (80)	11 (73)	10 (67)	12 (80)	11 (73)	2 (18)
South Asia	7	7 (100)	7 (100)	7 (100)	6 (86)	7 (100)	7 (100)	6 (86)	6 (86)	6 (86)	7 (100)	7 (100)	7 (100)	6 (86)	6 (86)	0 (0)
Western Europe	21	9 (43)	4 (19)	8 (38)	4 (19)	4 (19)	1 (5)	5 (24)	0 (0)	0 (0)	6 (29)	5 (24)	1 (5)	9 (43)	2 (10)	5 (45)
World Bank income level																
Low	22	21 (95)	21 (95)	20 (91)	21 (95)	21 (95)	20 (91)	19 (86)	10 (45)	8 (36)	18 (82)	19 (86)	20 (91)	15 (68)	16 (73)	0 (0)
Lower-middle	36	31 (86)	28 (78)	27 (75)	22 (61)	29 (81)	26 (72)	24 (67)	12 (33)	11 (31)	29 (81)	27 (75)	28 (78)	26 (72)	27 (75)	1 (9)
Upper-middle	41	27 (66)	31 (76)	28 (68)	21 (51)	33 (80)	25 (61)	22 (54)	8 (20)	11 (27)	29 (71)	22 (54)	25 (61)	23 (56)	22 (54)	1 (9)
High	57	30 (53)	22 (39)	26 (46)	15 (26)	20 (35)	12 (21)	21 (37)	0 (0)	1 (2)	22 (39)	21 (37)	12 (21)	25 (44)	11 (19)	9 (82)

Number of countries that reported shortages of each healthcare provider essential for kidney failure care, grouped by ISN region and World Bank income group. Percentages calculated as the number of responding countries divided by the total number of responding countries.

HD, haemodialysis; ISN, International Society of Nephrology; n, number of participating countries; NIS, Newly Independent States; PD, peritoneal dialysis.

inadequate training, reduced focus on scholarship and academic training, increased demand to meet quality of care standards and the development of new kidney failure care delivery models.<sup>27</sup>

This study provides data regarding the global availability of not only nephrologists and nephrology trainees, but also other healthcare professionals involved in kidney failure care. More than half of countries surveyed reported shortages in nephrologists, interventional radiologists for haemodialysis (HD) access and peritoneal dialysis (PD) access, surgeons for transplantation, HD access and PD access, as well as vascular access and transplant coordinators, counsellors or psychologists, dialysis nurses, and dietitians. Overall, these findings are consistent with data from the Global Burden of Diseases, Injuries and Risk Factors Study 2017, which reported shortages of physicians, nurses or midwives, and pharmacists in almost 50% of countries in all areas of medicine, not just nephrology. Similar to the findings of our study, the greatest shortages of healthcare workers were reported in sub-Saharan Africa, Southeast Asia, South Asia and Oceania.<sup>28</sup> Increasing the number of healthcare professionals in these regions and creating multidisciplinary teams are important, considering the complexity of care for patients with kidney failure. Furthermore, distributing the workload for kidney failure care across multiple providers would increase overall care capacity, which is particularly important in areas with significant nephrologist shortages. Another important component of kidney failure care is conservative kidney care, which is widely used as a method of providing non-dialysis medical management for patients with kidney failure.<sup>29–31</sup> Symptoms, quality of life, psychological, social and family support are essential for comprehensive conservative care. This study demonstrated shortages in counsellors/psychologists, who are essential healthcare professionals for conservative kidney care. Shortages were greater in low-income and lower-middle-income countries. In countries where kidney replacement therapy was limited or self-funded, conservative kidney care was an important alternative treatment strategy.

Specifically, country-level data regarding the distribution of kidney failure care and professional responsibilities can be used to tailor policies and ensure the effective utilisation of resources to address specific issues. These data can be used to guide workforce development and policy change initiatives across countries and regions. In order to create effective policies to expand local nephrology care, strategies will need to be tailored to each regional healthcare system based on available resources. For instance, in upper-middle-income countries, there are relatively fewer surgeons and interventional radiologists available for PD access compared with the number available for HD access. Resources can be used to increase the availability of physicians who can provide PD access, which may involve training existing HD surgeons and interventional radiologists to perform PD catheter insertions or expanding the scope of other

healthcare professionals, such as general physicians and/or community health officers (particularly in low-income countries), to perform PD catheter insertions. For this to be carried out effectively, nephrology care should be centralised by implementing public health strategies and creating national nephrology agencies to implement public policies and strategies to expand the nephrology workforce.<sup>31–34</sup>

This study provides international agencies, such as the ISN, with data regarding international variability in workforce shortages. Only 41% of low-income countries had nephrology training programmes.<sup>9</sup> The ISN sponsors medical trainees from developing countries to pursue fellowship training in nephrology with the goal of increasing the number of trainees and physicians in lower income countries,<sup>35</sup> in addition to many other initiatives that aim to increase the nephrology workforce in developing countries.<sup>36–40</sup> However, this study revealed a global shortage of not only nephrologists, but all healthcare professionals involved in kidney care, particularly in low-income countries. Therefore, expanding international initiatives to provide funding to train other healthcare professionals, and facilitating the redistribution of nephrology care to nurses and primary care physicians, may be a more time-effective and cost-effective method of addressing the global nephrology workforce shortage.<sup>41–42</sup> Healthcare training programmes will need to be modified in order to change professional scopes of practice and develop new competencies. For instance, this may involve nephrologists training to perform kidney ultrasounds, or nurses training to manage outpatient CKD care. This is particularly important in low-income countries, where the overall nephrology workforce is sparse, nephrology training programmes are limited, and the rates of CKD and kidney failure continue to rise.<sup>1–3,9</sup> Several strategies have been proposed for lower-middle-income countries regarding expanding their kidney failure workforces. These include: government provision of funding and infrastructure for kidney failure care; forming public-private partnerships with industry for kidney failure workforce training; using international nephrology societies to train, fund and expand the kidney failure workforce; creating partnerships with academic medical centres; and using web-based teaching programmes to train physicians, nurses and technicians.<sup>43</sup> While these strategies are useful, it has to be acknowledged that several competing public values, social and political dynamics as well as resource constraints may influence the achievement of the desired workforce goals for equitable kidney care across countries.

### Study limitations

Our study has some limitations worth noting. First, the lack of standardised frameworks or benchmarks to assess workforce adequacy limits our ability to draw firm conclusions across the diverse settings targeted by our survey. Second, like all questionnaires, our survey introduced the potential for subjectivity (ie, social desirability bias) and

was highly dependent on respondents' knowledge and perceptions. Although the survey questions were assessed for face validity, there was a baseline presumption that respondents accurately reported the status of the kidney failure workforce in each country. We strove to overcome this limitation by working closely with the ISN's regional boards to select respondents with a range of kidney care expertise to ensure adequate regional representation, and by corroborating findings with regional leaders and secondary data sources.

## CONCLUSION

Overall, nephrologists were primarily responsible for kidney failure care across all regions and countries of the world. Important gaps in workforce capacity exist, particularly in low-income and lower-middle-income countries. Efforts to increase workforce capacity in resource-limited countries are required to ensure high quality of care for patients with kidney failure.

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**Contributors** AB and DJ had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. AB, AL and DJ did the study concept and design. All authors did the acquisition, analysis or interpretation of data. PR, AB and FY drafted the manuscript. All authors made critical revision of the manuscript for important intellectual content. FY did the statistical analysis. AB, DJ and AL obtained funding. AB and DJ supervised the study.

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**Title:** Workforce capacity for the care of patients with kidney failure across world countries and regions

### **Supplementary Materials**

**Table S1:** The 160 countries that responded to survey questions regarding workforce for kidney failure care, grouped by ISN region

**Table S1:** The 160 countries that responded to survey questions regarding workforce for kidney failure care, grouped by ISN region

ISN region	Country				
<b>Africa</b>	Algeria	Congo, Dem. Rep.	Guinea	Namibia	Swaziland
	Angola	Congo, Rep.	Kenya	Niger	Tanzania
	Benin	Cote d'Ivoire	Liberia	Nigeria	Tunisia
	Botswana	Egypt, Arab Rep.	Libya	Rwanda	Uganda
	Burkina Faso	Eritrea	Madagascar	Senegal	Zambia
	Burundi	Ethiopia	Malawi	Sierra Leone	Zimbabwe
	Cabo Verde	Gabon	Mauritania	Somalia	
	Cameroon	Gambia, The	Morocco	South Africa	
	Chad	Ghana	Mozambique	Sudan	
	<b>Eastern &amp; Central Europe</b>	Albania	Cyprus	Kosovo	Moldova
Bosnia & Herzegovina		Czech Republic	Latvia	Poland	Slovenia
Bulgaria		Estonia	Lithuania	Romania	Turkey
Croatia		Hungary	Macedonia, FYR	Serbia	
<b>Latin America &amp; the Caribbean</b>	Argentina	Chile	El Salvador	Panama	Uruguay
	Bolivia	Colombia	Guatemala	Paraguay	Venezuela, RB
	Brazil	Cuba	Haiti	Peru	
	British Virgin Islands	Dominican Republic	Mexico	Puerto Rico	
<b>Middle East</b>	Iran, Islamic Rep.	Kuwait	Qatar	United Arab Emirates	
	Iraq	Lebanon	Saudi Arabia	West Bank & Gaza	
	Jordan	Oman	Syrian Arab Republic		
<b>NIS &amp; Russia</b>	Armenia	Belarus	Kazakhstan	Russian Federation	Ukraine
	Azerbaijan	Georgia	Kyrgyz Republic	Tajikistan	Uzbekistan
<b>North America</b>	Antigua & Barbuda	Canada	Jamaica	St. Lucia	Trinidad & Tobago
	Bahamas, The	Cayman Islands	St. Kitts & Nevis	St. Vincent & the Grenadines	United States
<b>North &amp; East Asia</b>	China	Japan	Macao SAR, China	Taiwan, China	
	Hong Kong SAR, China	Korea, Rep.	Mongolia		
<b>Oceania &amp; South East Asia</b>	Australia	Fiji	Malaysia	New Zealand	Singapore
	Brunei Darussalam	Indonesia	Myanmar	Philippines	Thailand
	Cambodia	Lao PDR	New Caledonia	Samoa	Vietnam
<b>South Asia</b>	Afghanistan	Bhutan	Nepal	Sri Lanka	
	Bangladesh	India	Pakistan		
<b>Western Europe</b>	Austria	Germany	Italy	Norway	United Kingdom
	Belgium	Greece	Liechtenstein	Portugal	
	Denmark	Iceland	Luxembourg	Spain	
	Finland	Ireland	Malta	Sweden	
	France	Israel	Netherlands	Switzerland	

ISN: International Society of Nephrology; NIS: Newly Independent States; SAR: Special Administrative Region; Rep: Republic; Dem: Democratic; RB: Bolivarian Republic; YVR: Yugoslavia Republic of Macedonia; PDR: People's Democratic Republic