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The global nephrology workforce: emerging threats and potential solutions!

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Abstract

Amidst the rising tide of chronic kidney disease (CKD) burden, the global nephrology workforce has failed to expand in order to meet the growing healthcare needs of this vulnerable patient population. In truth, this shortage of nephrologists is seen in many parts of the world, including North America, Europe, Australia, New Zealand, Asia and the African continent. Moreover, expert groups on workforce planning as well as national and international professional organizations predict further reductions in the nephrology workforce over the next decade, with potentially serious implications. Although the full impact of this has not been clearly articulated, what is clear is that the delivery of care to patients with CKD may be threatened in many parts of the world unless effective country-specific workforce strategies are put in place and implemented. Multiple factors are responsible for this apparent shortage in the nephrology workforce and the underpinning reasons may vary across health systems and countries. Potential contributors include the increasing burden of CKD, aging workforce, declining interest in nephrology among trainees, lack of exposure to nephrology among students and residents, rising cost of medical education and specialist training, increasing cultural and ethnic disparities between patients and care providers, increasing reliance on foreign medical graduates, inflexible work schedules, erosion of nephrology practice scope by other specialists, inadequate training, reduced focus on scholarship and research funds, increased demand to meet quality of care standards and the development of new care delivery models. It is apparent from this list that the solution is not simple and that a comprehensive evaluation is required. Consequently, there is an urgent need for all countries to develop a policy framework for the provision of kidney disease services within their health systems, a framework that is based on accurate projections of disease burden, a full understanding of the internal care delivery systems and a framework that is underpinned by robust health intelligence on current and expected workforce numbers required to support the delivery of kidney disease care. Given the expected increases in global disease burden and the equally important increase in many established kidney disease risk factors such as diabetes and hypertension, the organization of delivery and sustainability of kidney disease care should be enshrined in governmental policy and legislation. Effective nephrology workforce planning should be comprehensive and detailed, taking into consideration the structure and organization of the health system, existing care delivery models, nephrology workforce practices and the size, quality and success of internal nephrology training programmes. Effective training programmes at the undergraduate and postgraduate levels, adoption of novel recruitment strategies, flexible workforce practices, greater ownership of the traditional nephrology landscape and enhanced opportunities for research should be part of the implementation process. Given that many of the factors that impact on workforce capacity are generic across countries, cooperation at an international level would be desirable to strengthen efforts in workforce planning and ensure sustainable models of healthcare delivery.

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Key words: chronic kidney disease, nephrology workforce, planning, solutions

Introduction

Chronic kidney disease (CKD) is a major non-communicable chronic disease (NCD) and a key determinant of poor health outcomes in the general population [1]. It is a risk multiplier for many patients who have co-existing chronic medical conditions and its presence predicts a several-fold increase in all-cause and cardiovascular mortality [2, 3]. Globally, the burden of CKD continues to increase and current estimates suggest that between 8 and 16% of the world's population are affected. The estimated rates are even higher for certain high-risk subgroups—exceeding 50% in some cases [4]. Equally important, the prevalence of treated end-stage kidney disease (ESKD), the most advanced stage of CKD, continues to increase globally, and while >80% of all patients receiving treatment are from affluent countries, this pattern is likely to change as the burden of NCD increases for less wealthy countries and access to treatments improves for many developing countries [2]. The pattern of increasing global burden of CKD reflects a combination of many factors including higher detection rates, increasing population size and greater life expectancy.

Amidst the rising tide of CKD, the global nephrology workforce has shrunk and is failing to meet the growing healthcare needs of this vulnerable patient population [5]. In truth, this global shortage of nephrologists is seen in many parts of the world, including the USA, Canada, the UK, Europe, Australia and New Zealand, China, India, South East Asia, Africa and Latin America [5–20]. Moreover, many expert groups on workforce planning as well as national and international professional organizations predict further reductions in the nephrology workforce over the next decade, with potentially serious implications [21–24]. Although the full impact of this has not been clearly articulated, what is clear is that the delivery of care to patients with CKD may be threatened in many parts of the world unless effective country-specific workforce strategies are put in place and implemented. Consequently, there is an urgent need for all countries to develop a policy framework for the provision of kidney disease services within their health systems, a framework that is based on accurate projections of current and future disease burden, a full understanding of the internal care delivery systems and underpinned by robust health intelligence on current and expected workforce numbers required to support the delivery of kidney disease care. Given the expected increases in global disease burden and the equally important increase in many established kidney disease risk factors such as diabetes and hypertension, the organization, delivery and sustainability of kidney disease care should be enshrined in governmental policy and legislation [25]. Effective nephrology workforce planning should be comprehensive and detailed, taking into consideration the structure and organization of the health system operating in the country, the existing care delivery models, nephrology workforce practices and the size, quality and success of internal nephrology training programmes. This will provide valuable information so that workforce planning and implementation solutions are deployed in a timely and effective manner in each country to counteract the global epidemic of kidney disease [26]. In this article, we attempt to shed light on the developing global shortage in the nephrology workforce, possible causes and suggested solutions that may prove effective in the context of changing healthcare systems.

The global nephrology workforce

European countries

There is huge variation in the size of the nephrology specialist workforce across countries, which almost certainly impacts upon the availability and delivery of care for patients with kidney disease (Figure 1a and b). The Kidney Health for Life (KH4L) initiative supported by the International Society of Nephrology has provided valuable insights into the differences that exist in nephrology workforce numbers across a selection of European countries whose health systems are primarily publicly funded [27, 32]. In this survey of healthcare systems from 17 European nations with organized dialysis programmes, Italy had the highest number of nephrologists per capita (94 per 1000 ESKD patients) and Ireland had the lowest (5.7 per 1000 ESKD patients). Indeed, expressing the ratio as the number of nephrologists per million population (pmp), a similar pattern was observed, with countries such as Italy, Greece and Spain recording the highest ratios and countries such as Ireland, Turkey and the UK having the lowest ratios. What is remarkable is that despite these countries having well-established social health systems with highly organized structures for healthcare delivery, there remains substantial variation in the nephrology workforce. Whether this reflects a lack of workforce planning in some countries relative to others, a mismatch of nephrology supply to service demands, differences in healthcare delivery models that permit greater use of nurse specialists and physician extenders or possibly additional market forces deserves greater attention and focus.

United Kingdom

The UK is a good example where considerable attention has been devoted to matching staffing levels within the multidisciplinary kidney teams for renal service provision. In 2001, the British Renal Society assembled a multiprofessional National Renal Workforce Planning Group to prepare recommendations for staffing levels across each professional group involved in kidney care. This initiative was aligned with the Renal National Service Framework, a policy document that described the recommended standards of care and the indicators of good kidney care practice to be achieved for patients with CKD [33]. A fundamental goal was to provide valid information that could be used to best predict the future nephrology staffing levels to manage future cohorts of patients with CKD. They estimated that the appropriate staffing ratio was 1 nephrologist per 75 renal replacement therapy (RRT) patients or 1.0 work hour equivalent in nephrology per 100 dialysis/transplant patients. Their estimated staffing levels were based on future CKD growth projections in the context of a multidisciplinary kidney team. Moreover, these projections were provided under the assumption that many UK nephrologists in clinical practice have additional commitments to general internal medicine (up to 13 h/week). The number of nephrologists employed to manage CKD in the UK stands at 8.5 pmp, a number that sits at the lower end of the scale among European countries (Figure 1b). Moreover, >50% of nephrologists contribute to general internal medicine, reducing the time available for nephrology and kidney-based care. This careful workforce planning strategy in the UK has resulted in an overall increase in the nephrology workforce commensurate with rising ESKD numbers

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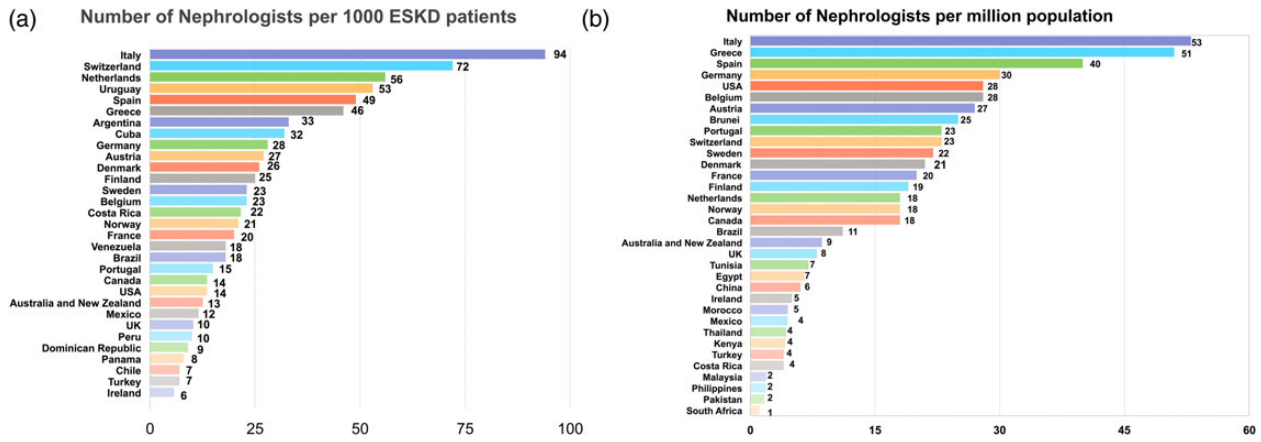

Fig. 1. (**a**) Number of nephrologists per 1000 ESKD patients by country (adapted with permission from Figure 1 in Bello [27]) [16, 19, 21, 22, 27–31]. (**b**) Number of nephrologists per million population by country (adapted with permission from Figure 1 in Bello [27]) [16, 19, 21, 22, 27–31].

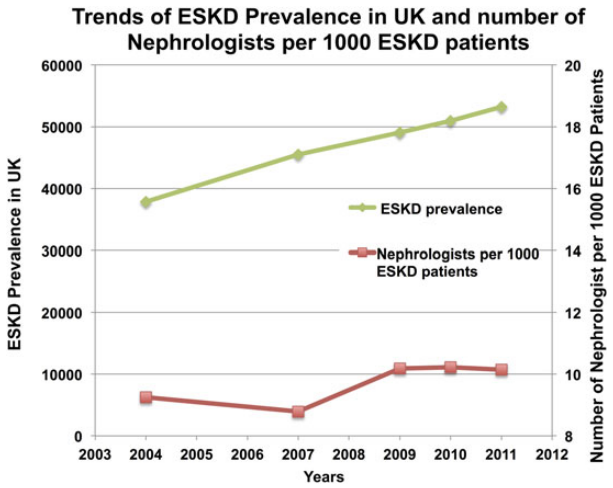

Fig. 2. Period trends in the prevalence of ESKD in the UK and the numbers of nephrologists per 1000 ESKD patients [34–39].

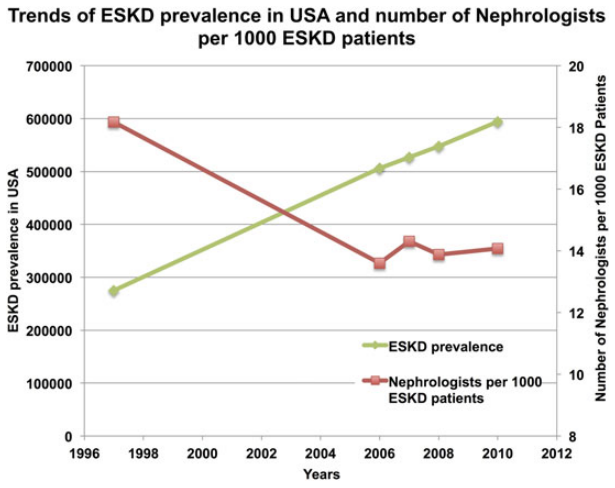

Fig. 3. Period trends in the prevalence of ESKD in the USA and the numbers of nephrologists per 1000 ESKD patients [42–49].

(Figure 2). It is also clear that the set of variables used to determine nephrology staffing levels in the UK are different from those used by some other European countries (e.g. Spain and Italy), where the number of nephrologists is 4- to 5-fold higher (Figure 1b).

United States of America

Several recent publications have highlighted recurrent concerns regarding the future of the nephrology workforce in the USA [6, 40]. The USA is one of the largest providers of RRTs in the world and ranks in the top three countries with the highest incidence rates and prevalence of ESKD per annum. Data from the US Renal Registry reported that 626 904 patients were receiving RRT in 2012, and this number is projected to rise to >775 000 by 2020, with >500 000 of these treated with maintenance dialysis [7, 41]. These facts would suggest that the current nephrology workforce should increase in order to compensate for the expected growth in patient numbers. Unfortunately, the opposite appears to be the case. In the USA, the number of nephrologists per 1000 ESKD patients has declined over the years, from 18 in 1997 to 14 in 2010 (Figure 3). This shortfall has occurred despite the fact that the number of nephrology fellows has increased almost 50%, from 628 in 1993 to 930 in 2013. According to Salsberg *et al.* [50], in a report prepared for the American Society of Nephrology (ASN), there were >9000 nephrologists engaged in direct patient care provision, and this translates to 28 nephrologists pmp. Moreover, there is a huge dependency on overseas medical graduates, with 40% of active nephrologists in clinical practice being international medical school graduates (IMGs) rather than US medical school graduates (USMGs). This statistic could pose major problems in the USA down the line should the federal government decide to change immigration policy or market conditions change globally. Equally concerning is the fact that the number of nephrologists is unequally distributed across the USA, from a high of 63 pmp in the District of Columbia to a low of 13 pmp in Iowa [51]. The implications of these statistics are 2-fold. First, it is possible for a specialty to have an adequate supply of specialists nationally but have major shortages within many communities across the country, reflecting a rural/urban divide. Second, one might further speculate that state-level variations and mismatches between supply and demand may lead to substantial differences in clinical practice.

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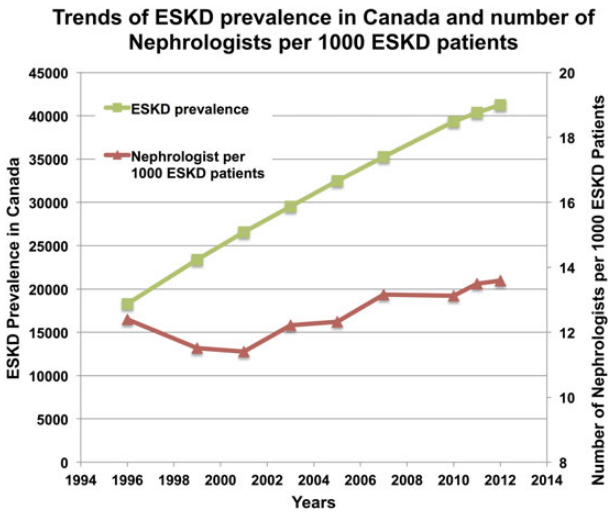

Fig. 4. Period trends in the prevalence of ESKD in Canada and the numbers of nephrologists per 1000 ESKD patients [52, 54–62].

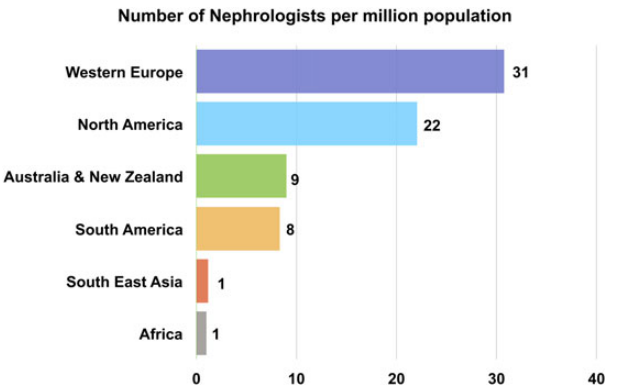

Fig. 5. Number of nephrologists per million population by continent [13, 15, 27–30, 40, 50, 52, 64].

Canada

According to the Canadian Medical Association Masterfile, there were 632 registered nephrologists working in 2014 [52] and this number equates to 18 nephrologists pmp. Comparatively speaking, Canada fares much better than many European countries in the size of the nephrology workforce, but these numbers are significantly lower than its nearest neighbour, the USA, with a reported 28 nephrologists pmp (Figure 1b). It is also clearly evident that there is a very unequal distribution of the nephrology workforce across Canada. For example, the numbers of practicing nephrologists were highest in the states of Newfoundland/Labrador and Ontario (at 21 pmp) and lowest on Prince Edward Island (at 14 pmp). What is remarkable is that there are no registered nephrologists in the Northwest, Nunavut and Yukon territories [53]. Moreover, and similar to many other western countries, the incidence and prevalence of ESKD has increased year after year over the last 20 years [54], which can further compound the mismatch between supply and demand (Figure 4). Despite the perceived shortage in nephrologists within Canada, a recent report from the Royal College of Physician and Surgeons in Canada found that a large number of subspecialists were surprisingly unemployed or underemployed [63]. In their report, they found that, among respondents, up to 16% of all new specialists or subspecialists reported being unable to secure employment, and that the principal drivers of this were related to the economy, the health system and personal reasons.

Australia and New Zealand

The Australian and New Zealand Society of Nephrology (ANZSN) reported 171 full-time equivalent nephrologists (136 full time and 82 part time) in clinical practice [21]. This number equates to 9 and 13 nephrologists pmp for every 1000 patients with ESKD. The Australian Nephrology Workforce Survey completed in 2007 identified several factors that could potentially impact the size of the nephrology workforce in future years. These included (i) the desire by many young nephrologists to retire early, (ii) the large percentage >55 years of age, (iii) on-call commitment in excess of 30 h/week and (iv) workload and clinical demands that were in excess of personal capacity [22]. This report made several recommendations, including better recruitment strategies, greater emphasis on regular workforce and workload predictions, workforce redesign with development of additional support positions and restructuring of the kidney health system.

Latin America

There are huge disparities in the distribution of the nephrology workforce in Latin America, with Uruguay registering 53 nephrologists pmp (the highest in the region), and Honduras reporting 1 nephrologist pmp (the lowest in this region), as seen in Figure 1a and b [28]. Even within a single country, such as Brazil (with a rate of 11 nephrologists pmp), there are significant regional mismatches between supply and demand, as most nephrologists are concentrated in the affluent South and Southeast regions [29]. On the whole, South America has 8 nephrologists pmp, similar to Australia and New Zealand (Figure 5). The burden of ESKD in Latin America has also increased significantly over the last 20 years, which currently stands at 660 ESKD patients pmp but still lags significantly behind the prevalence in the developed world [30]. The likely reason is underdiagnosis or undertreatment of ESKD, as there is no evidence that CKD is less prevalent in Latin America than in other parts of the world [29]. With increasing access to healthcare, it is likely that substantial growth will occur in Latin America, leading to worsening strain on already overstretched nephrology services and requiring major workforce planning and redesign.

Africa

Africa has the lowest number of nephrologists pmp in the world, with no nephrologists in many parts of the continent (Figures 5 and 6). The number of nephrologists pmp is highest in Tunisia and Egypt (7 nephrologists pmp). South Africa, one of the wealthiest counties on the continent, is estimated to have 1 nephrologist pmp, while most of the lower and lower-middle income countries, e.g. Sudan, Nigeria, Kenya, Ghana, Uganda, Rwanda, Zambia and Senegal, have numbers that are <1 nephrologist pmp [15, 65].

Asia

Asia is the biggest continent on the planet. The absence of national registries in some countries or published data on workforce planning makes it very difficult to get reliable information. Within South East Asia for example [including the countries of

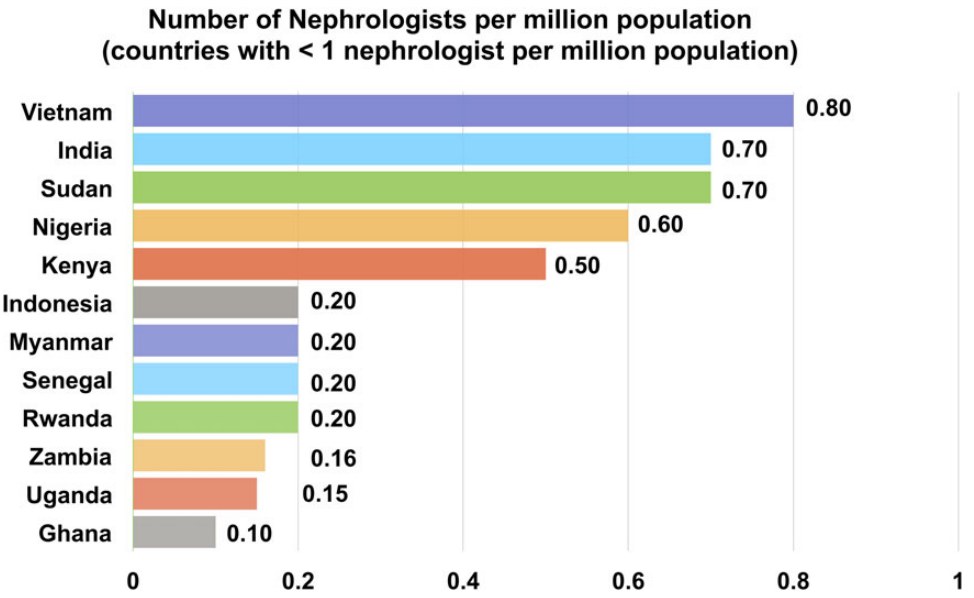

Fig. 6. Number of nephrologists per million population by countries with <1 nephrologist per million population [13, 15, 16, 64].

Brunei, Cambodia, Indonesia, Lao Peoples' Democratic Republic (PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam], there are substantial differences in economic prosperity and the gross national product. The economic challenges that exist for many of these countries are likely to greatly influence the size, structure, organization and delivery of kidney health services in their respective countries. In South East Asia there is 1 nephrologist pmp and the numbers vary from 25 pmp in Brunei to 0.2 pmp in Indonesia and Myanmar [13] (Figure 6). In China, the size of the overall CKD population is estimated to be 10.8%, or ~119.5 million [19, 66]. A nationwide Chinese survey conducted in 2008 identified only 8000 doctors registered as nephrologists [19]. This equates to 6 nephrologists pmp. In comparison with other developed nations, this would put China at the lower end of the scale; however, the size of the nephrology workforce within some regions is greater than that of some western countries. For example, according to a report in 2000, the total number of nephrologists registered in Shanghai was 418, equating to 30 pmp. Similarly, the number of nephrologists in Beijing and Guangzhou was equivalent to at least 30 pmp [67]. India and Pakistan are two of the most populous countries in the world, with an estimated population of ~1.5 billion. India has only 850 qualified nephrologists for a country of 1.2 billion people (0.7 pmp), whereas Pakistan has 250 for ~150 million (2 pmp) [16]. The absence of well-developed national registries and predictive modelling on CKD population growth hampers future planning. However, given the size of the combined Indian and Chinese populations, it is certain that huge growth will occur in these nations as RRTs become more affordable and increasingly available.

Potential threats to the nephrology workforce and possible solutions

It is becoming clear that multiple factors are responsible for the apparent shortage in the nephrology workforce and that the reasons may vary across health systems and countries. Published literature on this subject would suggest that the following are potential contributors: declining interest in nephrology among trainees [6, 14, 68], lack of exposure to nephrology among students and residents [12, 14], rising cost of medical education and specialist training [14, 69], increasing cultural and ethnic disparities between patients and care providers [70], increasing reliance on foreign medical graduates [52, 71], inflexible work schedules [72], increasing incidence and prevalence of CKD and ESKD [73], erosion of nephrology practice scope by other specialists [40, 74], inadequate training [74], reduced focus on scholarship and research funds [75], an aging workforce [21, 76, 77], demand to meet quality of care standards and the development of new care delivery models. Due to differences in models of renal care delivery across countries, it is evident that no single solution exists. We would advocate that a comprehensive evaluation be conducted in each country to define the scale of the problem, major determinants and the range of potential solutions needed, which may vary for each health system (Figure 7).

Declining interest in nephrology among trainees

There is good evidence to suggest that decreasing interest in the specialty of nephrology among medical students and junior doctors is a potential contributor to the current problem. A recent nephrology workforce report prepared for the ASN found that the number of USMGs selecting nephrology had declined continuously over the previous 12 years [50, 78]. Furthermore, despite an increase in the absolute number of fellowship training programmes and the number of available fellowship positions from 2002 to 2009, nephrology had attracted fewer applications over time [6, 7]. Equally worrisome is the fact that similar trends have been observed for foreign doctors, whose applications to nephrology fellowships have also decreased by nearly 20% in the past 5 years [7]. Should these trends continue, it is likely that a greater mismatch will occur between the national demand for kidney disease services and the available nephrology workforce unless the gap is filled by major changes in existing models of care.

The precise reasons for this lack of interest in nephrology as a specialty are multifactorial. First, many medical students and doctors in training consider nephrology's practice environment unappealing and believe that nephrologists work too hard for

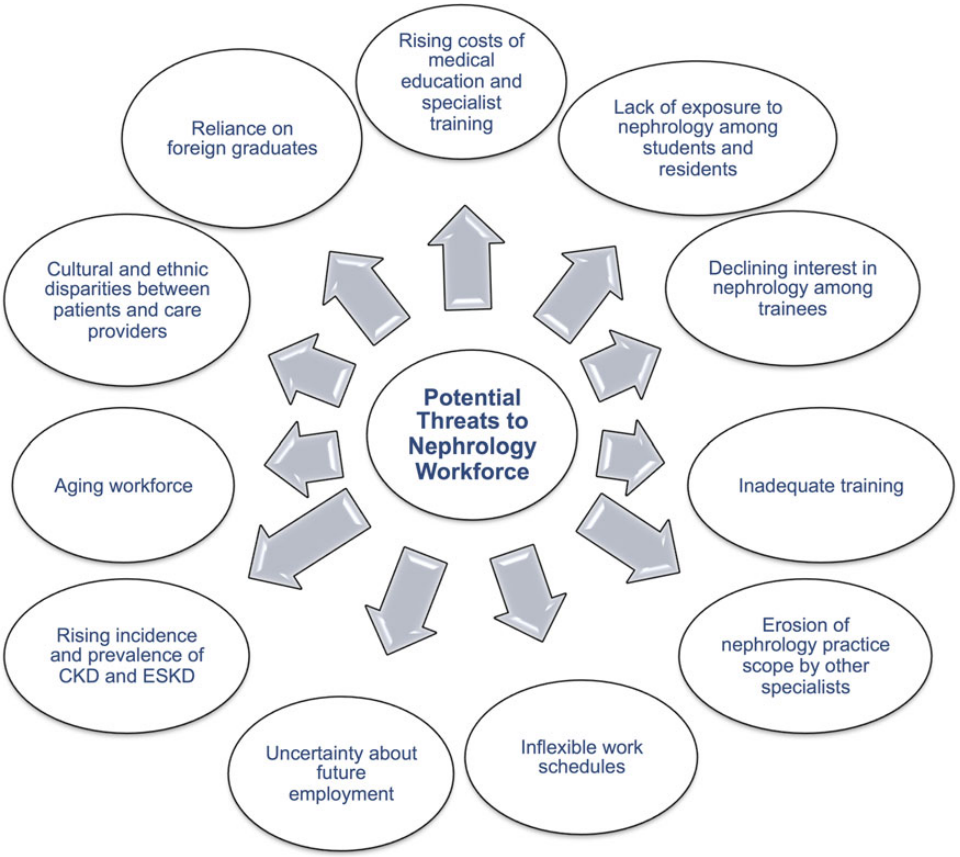

Fig. 7. Potential threats to the nephrology workforce.

the degree of remuneration and have a poor work–life balance. The survey by Dorsey *et al.* [79] provides us with deeper insight into the minds of trainees and their views on work–life balance in the context of subspecialty programmes. They have suggested that lifestyle-friendly specialties such as anaesthesiology, emergency medicine and dermatology are more popular among medical students graduating from highly ranked medical schools. The take-home message from this survey suggests that nephrology work schedules and programmes should embrace greater flexibility for modern graduates. Specialties that favour and facilitate greater personal time for leisure and family and fewer weekly hours spent on professional responsibilities tend to be the current leaders in recruitment [80].

Lack of exposure to nephrology

Several studies have cited the lack of early exposure to nephrology in both undergraduate and postgraduate training as a cause of the declining interest in nephrology [12, 14]. Early exposure to nephrology as a student and the complex range of challenges it offers is a crucial first step. Equally important, and perhaps not often cited, is the influence of a role model who can guide the student and demonstrate how nephrology provides diverse opportunities across the clinical, academic and professional landscapes. In modern-day undergraduate and graduate medicine programmes, not all trainees will have the opportunity to experience a rotation in nephrology. This leads to limited exposure of medical students and residents to the fascinating field of nephrology, dialysis and transplantation before they choose a final career path [14]. This point was highlighted by Lane *et al.* [12], who found that early exposure to nephrology was the principal reason for the choice of a career in a survey of 222 potential nephrology trainees from Australia. The benefits of early exposure at the undergraduate and postgraduate level in raising the profile of nephrology as a potential career path cannot be overemphasized. An early interest must be fostered throughout undergraduate training if students are to seriously consider nephrology as a career. There are many practical benefits of having students witness firsthand the diversity and complexity of kidney disease, its complications and treatments as well as the patient journey from one treatment modality to another. Students should be encouraged (and directed) to experience dialysis rounds, intensive care unit nephrology rounds, the setting up of a continuous RRT, placement of tunnelled dialysis catheters, exposure to native and kidney transplant biopsies and participation in the post-transplant follow-up of patients. Students and residents should also be encouraged to participate in nephrology-based clinical audits and research projects (basic science or clinical) in order for them get firsthand experience of the academic challenges and opportunities.

Erosion of nephrology practice scope by other specialists and changing the scope of practice

Nephrology grew as an adrenaline fuelled-specialty in 1960 when the primary focus was treatment of acute kidney injury (AKI) and electrolyte disturbance in the intensive care setting, leading to the traditional perception that nephrology is an

acute, hospital-based, interventional discipline with motivated consultant staff working long hours in a high-intensity environment. Many pioneer nephrologists were also excellent scientific investigators who later played key roles in developing new generations of cellular, molecular and epidemiological advances [8]. But clinical nephrology quickly matured into predominantly outpatient-based care of patients on RRT and CKD. The clearly defined boundaries of nephrology and its place as a specialty have shifted over recent years, and several core areas of nephrology, such as hypertension, renovascular disease, continuous RRTs and procedures such as kidney biopsy, have been annexed by other specialties [7]. In essence, we have lost considerable ground and our scope of practice has become constrained. This shrinking scope of nephrology practice has had an effect on recruitment and subsequent employment opportunities. The nephrologist's role with regards to care provided to ESKD patients is also ill-defined, with as many as two-thirds of nephrologists providing aspects of primary care to their patients [81].

To overcome this, the clinical scope of nephrology practice needs to be re-examined and redefined, with a focus on providing holistic care for patients with AKI and CKD and their associated complications. Nephrologists must be clear as to what bundle of care they should provide their patients, what skills and competences they should acquire, the range of procedural skills and to what extent they are responsible for the diagnosis and management of kidney disease. For example, it seems intuitive that a nephrologist should be able to image the kidney using ultrasound, assessing common pathologies without waiting for the radiologist to come to the clinic. If we are to gain control of our territory, we must be equipped with the skills and competencies to do so and reduce our dependency on other specialist providers who might further erode our scope of practice. These requirements must then be fully incorporated and mandatory within the nephrology curriculum. This will enthuse our students and trainees and help rekindle the passion that was once present.

Disparities between care providers and patients

A fundamental challenge in some countries such as the USA is to ensure that there is adequate representation of minorities by recruiting and training greater numbers of nephrologists from these groups. It is likely that the shortfall in nephrologists will exacerbate the disparity in the ratio of minority physicians to patients. In the USA, African Americans make up ~13% of the US population but comprise ~32% of the ESKD population [41]. The work of Powe [70] has highlighted the continued disproportionate effects of kidney disease on African Americans and its associated challenges. Indeed, one of the primary goals of the Healthy People 2010 initiative is to eliminate healthcare disparities in different medical conditions, and CKD has been designated one of the focus areas [82]. It is suggested that greater resolution of racial or ethnic disparities between patients and physicians may assist in eliminating adverse health outcomes. This can be achieved with increasing healthcare provider ethnic diversity. Because the numbers of minorities and poor individuals with CKD and ESKD are growing at faster rates than the general population, more fellows need to be trained in cultural competency and more nephrologists are required from cultural minorities and ethnic groups [83]. Efforts are needed to increase minority recruitment into nephrology training programmes, improving the imbalance in the racial background of trainees and patients in the hope of fostering improved trust between nephrologists and patients and improving standards of patient care [84].

Increased reliance of foreign graduates

More than 25% of practicing Canadian physicians graduated outside of Canada [52]. In the USA, 40% of nephrologists are IMGs, suggesting that a large part of the workforce within these countries is highly dependent on IMGs [85]. Similarly, in Australia, there is an increasingly greater dependency on overseas-trained doctors to fill training posts [71]. Heavy reliance on international graduates has the potential to upset the global workforce ecosystem, especially where active recruitment policies in one country exacerbate health system challenges in other countries, particularly those that face critical shortages. Achieving greater self-sufficiency through better and more attractive domestic training programmes is likely to prove a more favourable approach in the medium and long term.

Rising costs of medical education

The financial debt accumulated by medical students from attending medical school is likely to influence their choice of subsequent specialty, in particular if market forces predict lower income from one subspecialty versus another. In the USA, the median amount of educational debt for medical students in 2008 was $155 000, representing a 53% increase since 1998 [86]. Importantly, the monthly loan payment for a resident or fellow with a $155 000 debt could reach >$1700, amounting to ~48% of total pretax income. Findings from the 2014 Survey of Nephrology Fellows in the US shed some light on factors that may impact the choice of subspecialty. In this survey, >41.4% of USMG respondents and 8.5% of IMG respondents had accumulated debts of >$150 000 [87]. This is against a backdrop of several changes in dialysis re-imbursement policies by the federal government that has led to reduced earning potential for nephrologists [88]. While many factors will ultimately converge to affect the choice of a student's selecting a specific specialty, the financial burden of medical education is substantial. High student debts conspire to force medical students to choose subspecialties with higher earning potential, generating salaries high enough to pay down their debt. These factors, combined with competing lifestyle-friendly career options offered by other subspecialties (e.g. anaesthesiology, dermatology, ophthalmology and radiology), have reduced the interest and competition for nephrology fellowships. In 2009, 1196 fewer USMGs selected residency programmes in internal medicine than in 1985 [14]. In an ideal world, the selection of a medical subspecialty should be independent of financial pressures, including those from medical education.

Dialysis environment unattractive

The specialty of nephrology was traditionally considered unique in that it offered aspiring nephrologists a range of opportunities across the spectrum of acute and chronic dialysis, home therapies, kidney or kidney/pancreas transplantation and critical care nephrology as well as academic opportunities in clinical and basic sciences. However, the evidence would suggest that the role and scope of practice of the nephrologist has contracted over time with the relative expansion of other specialties. In some countries, the primary role for many nephrologists is in caring for chronic dialysis patients in the outpatient setting. This view is not appealing for trainees, who may consider working in a dialysis unit a constrained work environment and who would prefer a more challenging environment and greater diversity. The nephrology community needs to unshackle itself from this image and rekindle the spirit of the past, presenting itself as vibrant and clinically challenging,

modern and technologically innovative, continuously expanding and evolving in order to attract the best students and scientists [89].

Inflexible work practices

Given the increasing importance of work–life balance and greater attention by trainees to controllable lifestyle factors, doctors in training seek ways to achieve a much more balanced lifestyle. At the same time, representation of women in the medical profession has continued to improve, which has changed the dynamics of the medical profession from being a male-dominated profession to an even gender balance. Currently, depending upon the country and continent, ~30–50% of all medical practitioners are female, who are more likely to seek part-time work and retire early [86, 90, 91]. Nephrology has also welcomed this change with open arm and now one-quarter to one-half of nephrology trainees and nephrologists in developed countries are female [12, 92, 93]. Female nephrologists, similar to other physicians, tend to retire early, and as the American Medical Association Masterfile 2014 shows, the number of practicing female nephrologists decreases with advancing age, with only 11% of practicing nephrologists being women >65 years of age. This is in sharp contrast to the start of their careers (age 30–34 years), where 44% of working nephrologists are female [50].

Vocational flexibility is also an important factor in the choice of nephrology as a career, irrespective of gender. This argument is highlighted by Lane *et al.* [12] in a survey of 222 potential nephrology trainees about their perception of perceived motivators and barriers for a career in nephrology. They found that 80% of trainees cite vocational flexibility as a critical factor in their career choice. In addition, there is an international trend among physicians to work fewer hours [94]. All of these factors influence trainees to choose specialties that facilitate a certain lifestyle and therefore the specialty of nephrology suffers as a result. Needless to say, there is a need for greater flexibility to permit part-time and flexible work practices in order to accommodate interested trainees. Also, human resource practices should be changed so that part-time work is not considered second-rate employment. A good lead to follow is the National Health Service (NHS) Improving Working Life (IWF) initiative, which promotes a healthy work–life balance among all NHS employers [95]. This initiative has led to development of the NHS Flexible Careers Scheme, which allow doctors to (i) move in and out of part-time and full-time employment, (ii) find working arrangements for doctors desiring to work <50% of full-time, (iii) spread training over a longer period of time, (iv) restructure working hours, (v) take extended career breaks, (vi) wind down gradually before retirement and (vii) return to the NHS in some capacity after retirement [72, 89]. Similar approaches have been endorsed by a number of countries and appear to be a valuable mechanism for stabilizing and reversing the emerging workforce trends. It may sound contradictory, but it is possible that these measures could direct more physicians to choose nephrology as a career while retaining a work–life balance.

Uncertainty about prospective employment

An uncertain job market will always threaten the potential supply of any medical specialty in any economy. Although the numbers of CKD patients are increasing and the demand for kidney care services has increased, there are several other factors that have altered the market landscape and made nephrology less appealing. In the USA, there has been a decrease in all advertised positions across the healthcare market, with a 50% decline in advertised nephrology positions [96]. Furthermore, a recent report by the Royal College of Physicians and Surgeons in Canada found that 16% of all new specialists and subspecialists were unable to secure employment compared with 7.1% of all Canadians [63]. One of the major reasons behind the uncertain job market might be the urban/rural divide, where newly trained nephrologists want to work in urban areas while rural areas are still under served [6, 51]. This is evident from a 2014 survey of nephrology fellows, where only 7% of IMGs and no USMGs want to work in rural areas despite the fact that one-quarter of the USA population is rural based [87]. Other significant factors including uncertain international markets, financial crises, faltering economies and healthcare reforms have all played their part and led to delayed retirements and hiring freezes. While it is not easy to predict the future, a sensible pragmatic approach to workforce planning is required to protect against major threats to ensure sustainability.

A modern nephrology curriculum

To produce a highly trained nephrologist, training in theoretical, clinical and practical applications must be stimulating, compelling and robust across the platform of undergraduate and postgraduate education. A modern nephrology curriculum should engage students early on, captivate their interest, develop their skills, support competency-based assessments in the clinical and scientific fields and be delivered by a group of educators who are passionate about teaching and are role models in the field. There is good evidence that traditional curricula are inadequate for the needs of students and educators [6, 97, 98]. Recent studies highlight some of the gaps in the existing curricula. A modern curriculum should embrace problem-based learning and small-group teaching; exploit the advantages of social media; provide practical workshops on key subject areas such as dialysis, transplantation, CKD, AKI and diagnostic and treatment paradigms; and facilitate student participation in scientific studies. Ongoing curriculum reform and adaptation in order to train the nephrologist of the future is a fundamental requirement [99].

Ageing of the current nephrology workforce

Accurate workforce planning requires a detailed examination of the current workforce numbers and their demographic characteristics. An important variable that affects all medical specialties, including nephrology, is the aging of the healthcare workforce [76]. Based on the 2014 Physician Specialty Data Book, 35% of active US nephrologists were over the age of 55 years [100]. Correspondingly, 25% of Canadian nephrologists are >55 years of age [52]. Likewise, a report from the Australian Nephrology Workforce Survey conducted in 2007 found that almost 30% were over the age of 55 years [22]. This trend is not unique to nephrology; in the USA 40% of the current practicing physician workforce is >55 years of age while 33% of the nursing workforce is >50 years of age [101]. These data would suggest that approximately one-third of the current nephrology workforce will be eligible to retire in the next 10 years, leaving a potentially huge gap in resources for the training of future generations [77]. To counteract the impact of block retirements in any health system, it is necessary to have a programme with enough buffer capacity to withstand unexpected perturbations. The recruitment and training of adequate numbers of nephrology trainees is again an important consideration, but remains a challenging task for many countries. The alternative solution may involve changing

the model of care such that physician extenders, advanced care practitioners and other health professional take over tasks that are normally performed by nephrologists.

Alternative models of healthcare delivery

Change in the existing models of CKD care delivery may be the only effective method to manage the demands of increasing CKD burden against the backdrop of a reduced supply of nephrologists. One of the examples proposed is a collaborative model with a greater share of the work performed by allied healthcare professionals (e.g. physician assistants, renal nurse specialists, dieticians, social workers and renal pharmacists), however, in many countries, there already exists an insufficient supply of allied healthcare professionals, thus further fuelling a workforce capacity crisis. Indeed, a recent Europe-wide study found that effective multidisciplinary teams were available in only eight countries (Belgium, Denmark, Ireland, Italy, Netherlands, Portugal, Spain and the UK) to manage patients with CKD [27]. These existing paradigms need to change, with greater use of allied healthcare professionals in the domains of CKD, dialysis and transplantation. This would protect physician time and facilitate the management of higher patient workloads, while at the same time enabling delivery of efficient high-quality care [102]. These allied healthcare professionals may have the capacity and training to manage urgent dialysis referrals for interventional radiology, perform vascular procedures (e.g. tunnelled dialysis catheters), manage the transition from CKD to ESKD, prescribe dialysis treatments, monitor the adequacy of treatments on haemodialysis and peritoneal dialysis and develop and review patients at low-clearance CKD clinics and transplant clinics [103, 104].

Focus on scholarship and research funds

When there are shortfalls and capacity constraints in any health system, scholarship and research tend to be cut first. However, it is a fact that without scientific investigation there would be no dialysis or kidney transplantation. Accordingly, there is an onus on the renal community to ensure that research and scholarship remains at the forefront, both to advance our understanding of disease and to attract great minds into the field. There is evidence to suggest that student engagement in research at the undergraduate level tends to carry over into postgraduate careers and these students are more likely to pursue research careers. However, there are several threats to pursuing a research career after graduation: inadequate exposure as an undergraduate, financial debts from medical school, lack of research role models, lengthy time frame until independent funding, salary imbalance between research and clinical nephrologists, job security and the prevailing regulatory environment [78]. To overcome these shortcomings, newer strategies for funding nephrology training must be developed [105]. Because sources of funding for nephrology trainees are limited and increasingly subject to cuts, resources should be reallocated to areas where the maximum benefit can be achieved (e.g. prevention of CKD progression and maximizing the benefits of kidney transplantation). Although much work is needed, there is no reason why the clinical and research communities cannot come together as a single entity to meet these challenges [26].

Conclusion

In conclusion, we forecast the global burden of kidney disease will continue to grow due to the increased demand for care as the population ages. Our principal concerns are that many countries may not have given due consideration to (i) the future trajectory of CKD burden, (ii) the demands that this will place on a countries' health care system and (iii) the size of the nephrology workforce required to deliver an effective standard of care. Without adequate preparation and planning, a progressive mismatch may occur between the demand for kidney care services and the supply of a trained nephrology workforce. This may lead to a reduction in the quantity and quality of care globally, which would reversing the substantive progress that has occurred over the past 20 years. It is incumbent that leadership is provided by professional organizations and governmental departments in each country to effectively plan and predict the capacity of the healthcare system to manage the current and projected size of the CKD population. Effective training programmes at the undergraduate and postgraduate level, adoption of novel recruitment strategies, flexible workforce practices, greater ownership of the traditional nephrology landscape and enhanced opportunities for research should be part of the implementation process. Given that many of the factors that impact workforce capacity are generic across countries, cooperation at an international level would be desirable to strengthen workforce capacity and models of healthcare delivery. The onus is on the nephrology community to strengthen the global nephrology workforce and tackle current and emerging threats.

Conflict of interest statement

None declared.

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