Kidney
Diseases

Kidney Dis , DOI: 10.1159/000540152
Received: April 21, 2024
Accepted: June 26, 2024
Published online: July 24, 2024

Navigating the Global Economic Landscape of Dialysis: A Summary of Expert Opinions from The 4th International Congress of Chinese Nephrologists

Li PK-T, Ng JK-C, Cai G, Chen W, Chow KM, Fan S, He JC, Hooi LS, Pei Y, Teo BW, Wong MG, Wu I-W, Zhou J, Tian N, Ye Z, Yu X-Q

ISSN: 2296-9381 (Print), eISSN: 2296-9357 (Online)
https://www.karger.com/KDD
Kidney Diseases

Navigating the Global Economic Landscape of Dialysis:
A Summary of Expert Opinions from
The 4th International Congress of Chinese Nephrologists

#Philip Kam-Tao LI [1], Jack Kit-Chung NG [1,2], Guang-yan CAI [3] , Wei CHEN [4], Kai Ming CHOW [1], Stanley FAN [5], John Cijiang HE [6] , Lai Seong HOOI [7], York PEI [8], Boon Wee TEO [9], Muh Geot WONG [10], I-Wen WU [11], Jianhui ZHOU [3], Na TIAN[12], Zhiming YE[13], #Xueqing YU [13]

[1] Carol and Richard Yu Peritoneal Dialysis Research Centre, Department of Medicine & Therapeutics, Prince of Wales Hospital, The Chinese University of Hong Kong, Hong Kong SAR, China
[2] Li Ka Shing Institute of Health Sciences (LiHS), Faculty of Medicine, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, China
[3] Department of Nephrology, First Medical Center of Chinese PLA General Hospital, National Key Laboratory of Kidney Diseases, Beijing, China
[4] Department of Nephrology, The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, China
[5] William Harvey Research Institute, Queen Mary University of London, London, UK
[6] Department of Medicine, Division of Nephrology, Icahn School of Medicine at Mount Sinai, NY, USA
[7] Department of Medicine and Haemodialysis Unit, Hospital Sultanah Aminah Johor Bahru, Malaysia
[8] Division of Nephrology, Department of Medicine, University Health Network, Toronto, ON, Canada
[9] Division of Nephrology, Department of Medicine, Yong Loo Lin School of Medicine, National University of Singapore
[10] Department of Renal Medicine, Concord Repatriation General Hospital, NSW, Australia
[11] Division of Nephrology, Department of Internal Medicine, Shuang Ho Hospital, Taipei Medical University, New Taipei City 23561, Taiwan
[12]Department of Nephrology, General Hospital of Ningxia Medical University, Ningxia, China
[13] Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences, Guangzhou, Guangdong, China

Short Title: Economic Landscape of Dialysis

#Corresponding Authors:
Prof. Philip Kam-Tao LI, Carol and Richard Yu Peritoneal Dialysis Research Centre, Department of Medicine & Therapeutics, Prince of Wales Hospital, The Chinese University of Hong Kong, Hong Kong SAR, China
E-mail address: philipli@cuhk.edu.hk
ORCID: 0000-0001-9879-8388

Prof Xueqing Yu, Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences, Guangzhou, Guangdong, China
E-mail address: yuxueqing@gdph.org.cn

Keywords: chronic kidney disease, dialysis, kidney transplantation, economic burden, renal replacement therapy

Word (main text): 5412
Word (abstract): 224
Number of figures: 3
Number of tables: 2

Abstract
Background: Chronic kidney disease (CKD) continues to be a significant global public health issue. The escalating burden of CKD is probably driven by the aging population and the rising prevalence of diabetes. CKD not only adversely impacts an individual's health and well-being, but also poses significant challenge on the economy of the society. **Summary:** Experts from ten countries and regions around the world (Australia, Canada, China, Hong Kong, Malaysia, New Zealand, Singapore, Taiwan, United Kingdom, and United States) convened in the 4th International Congress of Chinese Nephrologists on 1st December 2023 to discuss the global dialysis burden. Although the cost of kidney replacement therapy (KRT) accounts for 2-3% of total healthcare expenditure in developed countries, patients with end stage kidney disease (ESKD) only represent a small percentage (<0.5%) of the population. Importantly, the economic impact of ESKD is not limited to direct medical costs, but extends to indirect societal costs, such as productivity loss by patients and caregivers. Primary prevention of CKD, early screening and treatment to delay progression to ESKD (where treatment costs rise dramatically), and utilization of home-based dialysis therapy (including peritoneal dialysis and home hemodialysis) shall be implemented as part of cost-containment strategy. Kidney transplant provides better outcomes than dialysis and is cost-effective in long run, whereas conservative kidney management should be considered for elderly frail patients. **Key messages:** Implementation of preventive measures and cost-effective treatment strategies are the cornerstone to combat the global CKD epidemic.

Introduction

Chronic kidney disease (CKD) has become a challenge to the global healthcare system. It was estimated that 846 million individuals worldwide had varying degree of CKD from stage 1 to 5 [1]. The Global Burden of Diseases (GBD) Study reported a global prevalence of CKD of 9.1% in 2017, which demonstrated significant geographical variation [2]. A recent systematic review suggested that approximately 434 million people have CKD in Asia, with most of the disease burden located in China (160 million) and India (140 million) [3].The global all-age mortality rate from CKD had increased by more than 30% from 2007, which exceeded the growth of other non-communicable diseases such as cardiovascular diseases (21.1%) and malignancy (25.4%) [4]. Besides being one of the leading causes of death, CKD also resulted in 35.8 million disability-adjusted life years (DALYs), with the highest DALYs reported in the low-income and low-middle-income countries (LLMIC) [2]. The observation of an increase in years lived with disability (YLDs) along with a reduction in years with life lost (YLLs) over the past two decades suggested that treatment strategies of CKD should not only focus on improving mortality rate but also the quality of life of CKD patients [5]. Furthermore, it is predicted that by 2040, CKD will rise from 16th place in 2016 to become the fifth leading cause of YLL [6].

Kidney replacement therapy (KRT) is a lifesaving but expensive treatment for patients who reach end stage kidney disease (ESKD). It was estimated that patients requiring KRT will increase from 2.6 million in 2010 to 5.4 million in 2030 [7]. It is noteworthy that the most dramatic growth was observed in Asia (from 0.97 to 2.16 million). This was likely due to the rapidly increasing number of CKD patients on this continent, which generated the largest treatment gap (1.9 million required but did not receive KRT) [3, 7]. Expenditure for KRT imposed enormous economic burden across countries. Although ESKD patients usually constituted less than 1% of total population, the cost of dialysis and transplantation consumed 2-3% of annual healthcare budget in high income countries [8]. It is not surprising that direct medical cost increased with the progression of CKD. In a recent pragmatic review that aimed at developing a global cost data library through engagement of local experts in 31 countries and regions, the average annual direct costs were found to increase by approximately 4 times from stage 3a to stage 5 (United States Dollars (USD) $3060 vs. $8736) [9]. The annual treatment costs of hemodialysis (HD) (mean: $57,334) and peritoneal dialysis (PD) (mean: $49,490) were substantially higher than that of pre-dialysis patients. Although the annual costs of kidney transplantation dropped significantly from US$75,326 at first year to US$16,672 in subsequent years, the medical cost per patient was still considerably higher than stage 5 CKD patients [9].

Economic evaluation is crucial in guiding policy makers to devise strategies for improved resource allocation and health service delivery [10]. Consequently, key opinion leaders from ten countries and regions (Australia, Canada, China, Hong Kong, Malaysia, New Zealand, Singapore, Taiwan, United Kingdom, and United States) convened in the 4th International Congress of Chinese Nephrologists on 1st December 2023 to discuss the dialysis burden around the world. This review summarizes the epidemiology, costs (direct and/or indirect), and funding policy related to CKD care, and proposes potential solutions to deliver sustainable and quality health care to patients with ESKD.

Australia and New Zealand

There were 15,518 patients and 13,507 patients receiving dialysis and kidney transplant respectively in Australia in 2022 [11]. The prevalence of patients on KRT was 1117 per million population (pmp) and 1069 pmp in Australia and New Zealand, respectively. Majority (82%) of those receiving KRT in Australia were on HD (54% dialyse in satellite HD units, 22% in-center HD units, and 7% home HD. Eighteen percent received PD. Together with home HD, home therapies made up of 25% of dialysis provision in Australia. As in Australia, HD was the main modality of dialysis in New Zealand (64% in-center HD and 12% home HD), whereas 24% patients received PD. The prevalence of home therapy in New Zealand was 36% which was higher in comparison to Australia. In both Australia and New Zealand, there were similar numbers of people on chronic dialysis compared to those with a kidney transplant (around 500 pmp) [11].

While both countries face an upward trajectory in the number of patients requiring dialysis, Australia generally reports a higher incidence probably due to a larger population size in comparison to New Zealand. Diabetes mellitus (DM) maintains as the leading cause of kidney failure (~40%). While prevalence of PD and home HD remains relatively stable, there is disproportionate increase in demand for in-center HD in New Zealand and a steadily increase in demand for satellite HD in Australia [11]. Australia tends to have a higher proportion of patients opting for HD over PD, while New Zealand shows a slightly higher PD usage despite HD remains the main modality of dialysis provision. Moreover, there is a shift in the age-group of people receiving dialysis in both countries. Although incidents patients stratified by age have not changed significantly over time, the peak prevalence by age group in Australia is 75–84-year-old, whereas in New Zealand, the peak prevalence by age group is 65-74-year-old. Elderly patients are often accompanied by higher comorbidities, shorter survival, increased demand of health and allied healthcare, that will add to overall cost to dialysis provision. Based on the Australia and New Zealand Dialysis and Transplant Registry (ANZDATA) [11], the probability of 5-year survival for dialysis patients in the 75–84-year-old in Australia was less than 30%, which is comparable to that of age group of 65–74-year-old in New Zealand. It is important to recognize that the socioeconomic burden of dialysis is often multifaceted. The cost is not limited to direct cost related to dialysis but extends to indirect cost for transportation, allied health, and careers that are often overlooked. Irrespective of countries or regions, the cost is highest for in-center HD follows by satellite HD and home therapies. The annual costs for HD and PD in Australia were comparable (US$44,432 and US$48,026 respectively) [12].

Advancement in healthcare provision requires innovation. The Affordable Dialysis Prize was jointly established by The George Institute for Global Health, the International Society of Nephrology (ISN) and the Asian Pacific Society of Nephrology (APSN) and supported by the Farrell Family Foundation, with the aim to promote development of an innovative dialysis system which can safely generate PD fluid at low running costs. The prize was awarded to Vincent Garvey's Ellen Medical Devices Point-of-Care (EM-POC) affordable PD system. Recently, the first proof-of-principle study reported that 60 bags of PD fluid generated by EM-POC system had no detectable microorganisms, suggesting that patients can produce sterile PD fluid from tap water at home [13]. These preliminary findings may make dialysis more affordable as well as accessible to underserved communities and resource-limited settings. This system was potentially more cost-effective than conventional PD as it saved the transportation cost of PD fluid.

Canada

According to a survey of digital healthcare records in 2019, 3.7% of Canadians had clinically diagnosed CKD while 7% of the population had measured CKD based on the presence of two pathological urinary albumin to creatinine ratio (ACR) or estimated glomerular filtration rate (eGFR) at least 90 days apart; 16% and 7% of the clinically diagnosed CKD patients had reached stage 4 and 5 disease, respectively [14]. On average, CKD incurred more healthcare cost than myocardial infarction, cerebral and peripheral vascular disease combined [14].

In 2021, the prevalence rate of ESKD in Canada was 1426 pmp, resulting in approximately 52,800 patients living with ESKD. By comparison, the incidence rate of ESKD in 2021 was 204 pmp which was 3 pmp more than in 2011 [15]. DM is the commonest cause of CKD, which accounted for more than 50% of all the incident cases of ESKD; diabetic patients with ESKD had an increased risk of mortality compared to non-diabetic patients with ESKD [16].

Among the prevalent patients with ESKD, 43% were treated with a kidney transplant (two-third from deceased vs. one-third from living donors), 42% on in-center HD, 12% on PD, and 3% on home HD [15, 16]. The 2021 prevalence and incidence rate of kidney transplantation in Canada were 47 and 0.9 pmp, respectively [15]. The rate of kidney transplantation in Canada was negatively impacted by the COVID-19 pandemic with a 13% decrease during 2020 but is starting to recover in 2022 [16].

A cost-minimization model from Canadian single-payer health care system reported that annual maintenance expenses were lowest in PD when compared with in-center HD and home HD [17]. The cost-effectiveness between in-center HD and PD were further compared between 39,318 dialysis patients (31,148 initiated facility-based HD and 8,170 initiated home PD) under Canadian Organ Replacement Register [18]. During a 10-year time horizon, patients who initiated PD were treated a lower cost-utility ratio than their HD counterparts (Canadian $83,762.00/quality-adjusted life year vs. $104,879.66/quality-adjusted life year), suggesting that initiation of PD was more cost-effective. On the other hand, given the rising incidence of diabetic kidney disease, it is imperative to start novel and effective treatment, including sodium-glucose cotransporter-2 (SGLT-2) inhibitor and glucagon-like peptide-1 receptor agonists (GLP-1 RA), to delay CKD progression and thus avoid consequent burden on dialysis [19, 20]. Enhancing the rate of kidney transplantation may also reduce the pool of patients with ESKD on dialysis.

China

The GBD study reported a total of 697.5 million cases of CKD (from stage 1 to 5) in the world in 2017 [2]. A recent systemematic reivew which evaluated the prevalence of CKD in Asia suggested that China had the greatest number of CKD patients (159.8 million), including 26.7 million in advanced stages (stage 4-5) [3]. This underscored the substantial CKD burden in China both within Asia and globally. Launched in 2010, the Chinese National Renal Data System (CNRDS) is a nationwide dialysis data collection system. It is one of the largest and most comprehensive national ESKD registry which captures demographic, clinical and laboratory data of dialysis patients [21]. Since 2012, government-operated medical insurance scheme reimbursed a large proportion of the KRT in China. Patients only needed to contribute a small amount for their KRT.

By the end of 2022, the CNRDS included data of 844,265 HD patients and 140,544 PD patients from 7298 HD centers and 1330 PD centers in Mainland China, respectively (Figure 1). In addition to the rising number of prevalent dialysis patients, the average age of prevalent dialysis patients also rises from 53.1 in 2011 to 57.8 in 2022, while that of incident dialysis patients increased significantly from 52.8 in 2011 to 59.0 in 2022. The relative proportion of etiologies of ESKD varies according to the race and geographical regions of China [22]. Data from the CNRDS 2022 showed that glomerular diseases was the most common cause of ESKD (40.1%), followed by diabetes (21.1%) and hypertension (11.8%). However, for the incident dialysis patients, diabetes has exceeded glomerular diseases to become the top cause of ESKD in 2022, with proportion rate 29.9% and 28.7%, respectively.

Among the dialysis population in the CNRDS registry, HD accounted for 84.3%, while PD accounted for 15.7%. According to the China Kidney Disease Network (CK-NET) 2015 annual data report, while

HD and PD patients constituted only a small percentage (0.16% and 0.02%, respectively) of the entire insured Chinese population, they incurred a disproportionately high percentage of healthcare expenditures (2.08% and 0.34%, respectively) [23]. It was estimated that the annual costs of incident HD and PD patients were 10.4 billion Renminbi (RMB) and 0.6 billion RMB, respectively, in 2017 [24]. To increase accessibility of KRT in China, the Chinese government advocates national PD utilization by constructing a complementary system that combines PD with HD, introducing new insurance systems (especially in rural areas) for better coverage of ESKD, and initiating and supporting the local production of PD solutions. At the regional level, the success of PD was exemplified by the 'Guangzhou model' established by the Sun Yat-sen University, which highlighted the importance of a well-trained PD team, designed patient training program and coordinated follow-up [25, 26]. They also initiated the PD training program in 13 satellite centers in Guangzhou, which laid the foundation for the subsequent National Dialysis Unit Training Program for County Hospital, that provided PD training to 3,166 medical staff from 2,097 county hospitals in China.

Hong Kong

From 2012 to 2022, the incidence rate of ESKD patients requiring KRT increased by nearly 20%, from 164.6 to 197.4 pmp, in Hong Kong. Among patients who began dialysis, DM was reported as the primary cause in 54.9% of cases in 2023, compared to 45.8% in 2010 [27].

A more comprehensive picture of economic burden could be obtained by conducting cost analysis from both the health provider and societal perspectives [28-30], as shown in Figure 2. This approach can capture the total costs, including patients' out-of-pocket expenditure and productivity loss due to unemployment, morbidity and mortality. Of note, indirect costs also take into account third-party payer, such as the productivity loss as a result of caregiving and incremental healthcare costs incurred by caregivers. Hong Kong has adopted the 'PD-first policy' for over 35 years [31]. Recent studies which aimed at quantifying the economic burden of ESKD in Hong Kong showed that annual direct and overall costs of in-center HD were the highest among three competing dialysis modalities (PD, in-center HD and nocturnal home HD) [28, 29]. Patients on PD had lower first-year societal cost but higher second-year costs than those on nocturnal home HD [29]. In a simulated lifetime cost-effective analysis, PD was the most cost-saving modality which well dominated in-center HD [28]. Compared with PD, the incremental cost-effectiveness ratio (ICER) of nocturnal home HD was US$16,934 and US$1,195 per one additional quality-adjusted life-year (QALY) gained from healthcare provider's and societal viewpoints, respectively [28]. Both ICER are within the acceptable thresholds based on opportunity costs, which supported the utilization of home-based therapy – be it PD or nocturnal home HD. Most nocturnal home HD programs require long training period up to three months or more. Patients also need extra space for installation of the HD machine and the reverse osmosis machines. A novel NxStage System One HD machine has been introduced to Asia recently [32], aiming for a low-dialysate volume approach and utilization of a simple design and much smaller footprint. There are additional advantage of obviating home plumbing or electrical system modifications [33]. Furthermore, incremental dialysis have been shown to reduce health expenditure, as well as plastic waste and water consumption, which may reduce the adverse impact on environment [34]. In addition to the various dialysis options, palliative care could also be considered as this is another cost-effective strategy [35]. A recent economic evaluation comprising 183 CKD patients aged over 65 years showed that comprehensive conservative care was a preferable and more cost-effective treatment option than HD, regardless of the quality-of-life measure used for QALY calculations [36].

Malaysia

The overall prevalence of CKD in Malaysia is 15.5% of which 6.8% belong to stage 3 -5. In 2022, the incidence of KRT was 293 pmp for dialysis and 6 pmp for kidney transplantation, respectively. The prevalence of treated KRT was 1,626 pmp, with 53,164 on treatment. HD made up 84.7% of the total, PD 11.7%, and transplantation 3.6% [37]. Malaysia has a low rate of kidney transplant, and the predominant modality is in-center HD with hardly any home HD. Government is the main source of funding for dialysis: direct government funding 48.7%, social security organization 24.2% and "zakat" 11.6% making a total of 84.5%. (Zakat is the tithe mandatory on all Muslims who have excess income). Historically, the public sector was the main dialysis provider, but in 2022 its share was 29.4%. Over the last 10 years the private sector had grown rapidly and provided for 53.8% in 2022, while the remaining 16.8% was from non-governmental organizations (NGO) [38].

For incident patients, age $\geq$ 65 and 55 – 64 years is increasing more rapidly than younger age groups. For prevalent patients, age groups 45 – 54, 55 – 64 and $\geq$ 65 years now predominate compared to younger ages. The leading cause of primary renal disease is DM, which accounts for 52% of new dialysis patients.

The cost utility of HD versus PD was estimated in 2017 [39, 40]. HD patients had better survival but lower health-related quality of life score than patients on continuous ambulatory peritoneal dialysis (CAPD). The cost per QALY gained was Malaysian Ringgit (MYR) 46,595 for HD and MYR 41,527 for CAPD, giving to a cost ratio of HD to PD of 1.12. This was comparable to the cost-utility ratio of HD/PD (1.19) in Thailand in 2004 [35].

In Malaysia, the main cost of CAPD is the dialysis consumables (70.5%). A multinational company set up a factory in Malaysia to manufacture a PD system in 2016. The system Stay Safe Link® was compared to the original imported system Stay Safe® in a randomised controlled trial comprising of 472 patients in 2017 [41]. This study demonstrated that the peritonitis rate of Stay Safe Link® was non-inferior to that of Stay Safe (0.03 vs. 0.04 episode per patient-month; incidence rate ratio 0.91, 95% CI 0.85 to 1.28); but there were more device defects for Stay Safe Link® (risk ratio 2.57). It is hoped that with the manufacture of a safe product within the country, the price of PD consumables will reduce over time and thus reduce the burden on the healthcare budget. Along the line, there are ongoing effort and planning to manufacture erythropoiesis-stimulating agent (ESA) locally for cost-reduction purpose [42]. A large amount of health resources that are currently spent on each patient with ESKD raises concerns about the opportunity cost of KRT, especially dialysis, that could otherwise be spent on more cost-effective measures (such as primary and secondary preventive measures) to attain better health outcomes [43].

Singapore

According to the Singapore Renal Registry 2021 report, the age-standardized incidence rates (ASIR) of stage 5 CKD were 266.7 pmp and 295.3 pmp in 2011 and 2019, respectively [44]. The ASIR of definitive dialysis (survived on dialysis >90 days) increased from 169.6 pmp in 2011 to 187.3 pmp in 2020. Diabetic kidney disease was the main cause of ESKD and accounted for 67.8% of patients who initiated dialysis in 2020. Men (56.2%) outnumbered women (43.8%, $p < 0.001$). On the other hand, ASIR of kidney transplant was 23.0 pmp in 2008, followed by a decline to 13.9 pmp in 2012. The surge in ASIR in 2017 (21.2 pmp) was possibly negatively impacted by COVID-19 pandemic, which was refected by a decline to 10.7 pmp [44].

To reduce the economic burden of ESKD, more efforts should be made to focus on (1) preventing kidney disease, (2) improving screening for CKD, (3) better management of pre-dialysis CKD, and (4) increasing PD utilization and kidney transplantation to improve cost-effectiveness.

In April 2017, the Holistic Approach to Lowering and Tracking Chronic Kidney Disease (HALT-CKD) program was started nation-wide to improve the management of patients receiving subsidized primary care at polyclinics by identifying and tracking all CKD patients [45]. The initial goal was to optimize the use of renin-angiotensin-aldosterone system (RAS) blockers and ensure that as many patients as possible could achieve recommended blood pressure goals. Furthermore, patients with more advanced CKD (stages 3b to 5) are referred to nephrologists for shared care, and there are plans to include private family practices or general practitioners [46]. Earlier referrals to nephrology specialty can expedite the utilization of evidence-based medications (e.g., SGLT-2 inhibitors and novel non-steroidal mineralocorticoid receptor antagonists) prior to general licensure to retard CKD progression.

Besides better medical management, a whole of society lifestyle change is required to truly make an impact on reducing diabetic kidney disease. The labeling and advertising prohibition measures for beverages sold in Singapore in pre-packaged form and from non-customizable automated beverage dispensers came into effect on 30 December 2022 [47]. Moreover, the Ministry of Health is studying regulatory measures to restrict salt intake in general population given the rising prevalence of hypertension [48]. One of the measures was to encourage suppliers to replace regular salt with lower-sodium alternatives, such as potassium salt. In addition, the Ministry of Health launched a national enrolment program, the Healthier SG program, for residents to commit to seeing one family doctor and adopt a health plan [49]. The program will mobilize family doctors to deliver preventive care, develop health plans that include lifestyle adjustments, regular health screening and appropriate vaccinations. It will also activate community partners to support residents in leading healthier lifestyles.

Taiwan

ESKD is highly prevalent in Taiwan, with an incidence of 525 pmp and a prevalence of 3772 pmp [15]. The prevalence of CKD is projected to increase from 10.6% in 2022 to 12.4% by 2027. However, underdiagnosis of CKD remains common. Taiwan has a single-payer healthcare reimbursement system provided by the National Health Insurance and dialysis therapy has been fully reimbursed since 1995. The care of kidney patients comprised approximately 10 % (19 billion USD) of the overall healthcare expenditure every year [50], indicating urgent policy interventions to reduce disease burden and economic.

In order to combat the high disease burden of CKD, the Taiwan Society of Nephrology (TSN) initiated a series of CKD care plans, and collaborated with the Bureau of National Health Insurance and the Bureau of Health Promotion to provide more comprehensive care for patients suffering from kidney disease since 2003. Over the past 20 years, multidisciplinary care programs have been implemented including the setup of CKD health-promotional centers, Pre-ESKD care project, Early CKD care project, and automatic GFR report in preventive health service for adults [51].

Currently, more than 70% of patients entering dialysis in Taiwan have been managed under pre-ESKD care project, which is operated by nephrologists, nursing educators, nutritionists, and pharmacists. Additionally, over 30% of patients with early CKD have received care through the Early CKD care project. There are over three hundred kidney health promotion institutes that adopt multidisciplinary cares to improve kidney literacy and case management for CKD [52]. Moreover, integration of comprehensive care for diabetic kidney disease programs involving endocrinologists and nephrologists has also been planned since 2022. This program emphasizes mandatory checking of urine ACR and eGFR at least every 6 months for every diabetic patients, and employs a 'pay by performance' structure. In addition, by implementing shared decision-making (SDM) and the Patient Autonomy Act, TSN aims to improve the life quality of ESKD patients by promoting conservative care for elderly patients. Through SDM with elderly ESKD patients, nephrologists discuss advanced care planning and/or dialysis withdrawal after identification of appropriate patients with multiple comorbidities. The use of hospice program has doubled from 8.5% in 2016 to 16.7% in 2020.

United Kingdom

In the United Kingdom (UK), approximately 7.2 million adults are living with CKD of various stages, giving to a prevelance of 12.8% in 2023 [53]. The total number of CKD patients is projected to increase to 7.6 million in 2033. Importantly, CKD is predicted to be the fifth leading cause of premature death by 2040 in UK. Additionally, CKD care consumes £7.0 billion in annual healthcare expenditure. This includes £6.4 billion of direct medical costs to the National Health Service (NHS), and further £372 million productivity loss for people living with ESKD and the people who care for them [53].

It is accepted that where suitable, kidney transplantation offers patients better quality of life compared to remaining on dialysis and is cost effective. For this reason, it is reassuring that from 2011 to 2019, there has been an increase in number of patients with a functioning kidney transplant [54]. In fact, data suggest there has been 15-20% reduction in patients who are active on the transplant waiting list over the past decade. This was probably attributed to the increase in nondirected altruistic live donors, success of the donor exchange schemes and increasing use of extended criteria deceased donors (Figure 3).

SDM with patients and their family is central to modality choice in UK. But it is recognized that in the UK, due to high staffing cost, home dialysis treatment (CAPD, automated PD (APD) and home HD) is cheaper that in-centre HD (either in Hospital or Satellite). The Getting It Right First Time (GIRFT) report recommended that a minimum of 20% of dialysis patients should be on a form of home dialysis therapy at each renal centre to improve their quality of life and independence [55]. Currently, the average home dialysis population is approximately 17.5% but this mask wide geographic variations from centre to centre (Figure 3).

It is generally accepted that cost of CKD would be better contained through primary prevention to retard progression of CKD to ESKD. Public health initiatives are important, which is exemplified by the government engagement with food industry to reduce salt added to processed foods. This has led to reduction of the average salt intake from 8.8g/day in 2005 to 8.0g/day in 2014 [56]. The reduction of salt intake of 10% over 10 years contrasts to the more dramatic reduction of sugar added into soft drinks (30% reduction over 2 years) sold in UK consequent to UK Sugar Tax in 2018. Whilst the importance of these changes is acknowledged, the sugar tax is only part of wider anti-obesity policy.

Improving primary care of patients at risk of ESKD has been a particular focus for the NHS. Unfortunately, albuminuria or proteinuria testing remains suboptimal even for patients coded to have hypertension or CKD. Earlier study showed that 75% diabetic patients with proteinuria was diagnosed based on urine dipstick testing rather than formal urine ACR [57]. This had important implications as higher urine ACR was shown to trigger prescription of angiotensin-converting enzyme inhibitors (ACEI) or angiotensin receptor blocker (ARB) in subsequent 6 months [58]. The NHS North East London Commissioning Group have established a collaborative Joint Working Project to improve screening for albuminuria. This project utilises a home-based albuminuria screening test linked to a smartphone App. Briefly, the participants will receive a self-testing kit (Healthy.io, Tel Aviv-Yafo, Israel). The participants follow the instructions to perform urine dipstick at home and scan the dipstick using smartphone App. The colour of dipstick will be transformed into urine ACR results, which is uploaded into their electronic primary care record via a smart phone application. It is envisaged that this project will identify patients and increase prescribing of ACEI/ARB and SGLT-2 inhibitors. However, there needs to be wider evaluation of this smartphone application whether it may increase health inequalities through reduced acceptance in elderly and people from low socio-economic backgrounds [59].

United States

In 2021, 13.5% of 23.9 million Medicare Fee-for-Service (FFS) beneficiaries aged ≥66 years had a diagnosis of CKD, yet they accounted for nearly one-quarter (24.1%) of total Medicare FFS spending, or US$76.8 billion. Between 2011 and 2021, there were decreases in spending for individuals with DM and heart failure (HF), but a 40% increase (from US$54.9 billion to US$76.8 billion) for individuals with CKD [15].

The incidence rate of ESKD gradually declined to 363 pmp in 2021. Notably, while the majority of incident cases (83.8%) began with in-center HD, 12.7% patients initiated PD, which continued to rise since 2008 [15]. This was possibly related to the implementation of Medicare prospective payment system, which bundled dialysis and medications into a single payment [60]. This Medicare payment reform enhanced PD initiation and reduced switch from PD to HD. The prevalence of ESKD declined to 2219 pmp in 2021, which represented a decrease of 3.5% since its peak in 2019 [15]. The percentage of Medicare spending for patients with ESKD had been stable from 2011 to 2019, with the ESKD population accounting for about 7% of total Medicare expenditures annually. However, inflation-adjusted total Medicare FFS expenditures increased in 2020 by approximately 12% while ESKD FFS expenditures decreased by 4.6% to US$37.5 billion. As such, the ESKD population accounted for 6.1% of total Medicare FFS expenditures in 2020.

The prevalence of diabetes increased markedly from 2005-2008 to 2017-March 2020 among individuals with and without CKD, reaching 9.5% among those without CKD and 35.6% among those with CKD [15]. There was considerable overlap among CKD, DM, and heart failure (HF). Importantly, per-person per-year (PPPY) costs for older adults with CKD, DM, and HF in 2021 were 2.5 times as high as the cost for beneficiaries with CKD. This reinforced the importance of early detection and optimization of glycemic control and other CV risk factors. In this regard, SGLT-2 inhibitors, which was associated with better cardiorenal outcomes in CKD patients, were shown to be cost-effective [61]. Compared to those receiving standard of care alone, patients with baseline diabetic kidney disease receiving SGLT2i experienced more life-years (1.27) and discounted QALYs (0.67). The ICER of US$ 25,974 per QALY were below a commonly recognized threshold of US $15,000 per QALY, supporting its cost-effectiveness [61].

In inflation-adjusted dollars, PPPY expenditures for beneficiaries receiving HD decreased by 13.2% from US$114,391 in 2011 to US$99,325 in 2021. Similarly, for PD, PPPY cost decreased by 8.2% from US$94,780 to US$86,976 [15]. In a retrospective analysis including 8305 propensity-matched pairs of HD: PD patients who were aged ≥ 67 years and began dialysis between 2008 and 2015, the cost ratio between HD to PD was 1.11 (95% CI 1.09 – 1.03) [62]. HD was associated with significantly higher intravenous drug cost and rehabilitation expenditure [62]. On the contrary, PPPY spending for kidney transplant recipients were lowest among the three modalities of KRT. Specifically, PPPY spending for kidney transplant recipients (US$ 43,913) was approximately half that of patients receiving PD. Interestingly, this was 3 times higher than the mean annual treatment cost of kidney transplant (US$ 16,672) from a global library of costing studies [9], suggesting kidney transplant may be a particular cost-saving strategy in some countries.

Given the difference in cost of different modalities, the Kidney Health Initiative (KHI) announced in 2019 emphasized on the increase of transplant and home dialysis utilizations for incident ESKD patients [63]. The Centers for Medicare and Medicaid Services (CMS) announced a new model of care for CKD patients in 2020. This End-Stage Renal Disease Treatment Choices (ETC) Model proposed a new payment system where providers were incentivized for encouraging care providers to build their home dialysis program. The ETC Model also incentivized transplantation by financially rewarding facilities and clinicians based on their transplant rate calculated as the sum of the transplant waitlist rate and the living donor transplant rate.

Discussion

ESKD not only adversely impacts an individual's health and well-being, but also imposes a heavy burden on the economy and healthcare system of society. Table 1 summarizes the incidence and prevalence of ESKD patients, and the dialysis funding models in the 10 countries/regions participating in this conference [11, 15]. Besides, the challenges posed by the global ESKD burden include rising number of ESKD patients worldwide that require KRT, aging dialysis patients who have more comorbidities and greater susceptibilities to complications, increasing cost of dialysis consumables and increasing prevalence of diabetes (Table 2). The need for securing sufficient medical and nursing manpower in the care of CKD patients is highlighted including recruitment, training and retention. In prevention, multidisciplinary input including primary care and general physicians together are essential to provide sufficient care to the large number of CKD patients that we have.

Estimates of healthcare costs for kidney disease used to be listed from the health provider perspective. But societal or indirect costs, which include but are not limited to productivity loss of patients and their caregivers, should also be considered. It is also critical to recognize that the economic burden increases remarkably with progression of CKD severity, especially to the juncture that requires KRT [9]. Therefore, it is important to advocate identification and modification of risk factors for CKD (e.g., obesity and diabetes), early detection of CKD (by screening urine ACR and eGFR) and timely treatment by effective therapies (in particular SGLT-2 inhibitors) to slow down progression to ESKD [64]. If dialysis is deemed necessary, home-based dialysis (PD and home HD) are preferred due to their cost-effectiveness and better patient acceptance. In addition, efforts should be dedicated to promoting kidney transplant (especially living related transplant), as well as implementing comprehensive conservative kidney management in frail elderly CKD patients [65]. Finally, economic evaluations, preferably using data from KRT registry, are invaluable in quantification and surveillance of disease and economic burden, which is essential to inform policy makers in planning sustainable and affordable kidney care.

Statements

Written consent or ethic approval from institutional review board are not required because individual patient data are not involved in this narrative review.

Acknowledgement

The authors thank the support from Australia and New Zealand Dialysis and Transplant Registry.

Conflict of Interest Statement

The authors have no conflicts of interest to declare in relation to this article.

Funding Sources

This study was not supported by any sponsor or funder.

Author Contributions

Philip Kam-Tao Li, Jack Kit-Chung Ng, Guang-yan Cai, Wei Chen, Kai Ming Chow, Stanley Fan, John Cijiang He, Lai Seong Hooi, York Pei, Boon Wee Teo, Muh Geot Wong, I-Wen Wu, Jianhui Zhou, Na Tian, Zhiming Ye, Xueqing Yu conceived the ideas of this review and conducted literature search. Philip Kam-Tao Li and Jack Kit-Chung Ng prepared the draft of manuscript and revised the manuscript. All authors provided intellectual input and endorsed the final manuscript.

References

1. Kovesdy CP. Epidemiology of chronic kidney disease: an update 2022. Kidney Int Suppl (2011). 2022;12(1):7-11.
2. GBD Chronic Kidney Disease Collaboration. Global, regional, and national burden of chronic kidney disease, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2020;395(10225):709-33.
3. Liyanage T, Toyama T, Hockham C, Ninomiya T, Perkovic V, Woodward M, et al. Prevalence of chronic kidney disease in Asia: a systematic review and analysis. BMJ Glob Health. 2022;7(1).
4. GBD 2017 Causes of Death Collaborators. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):1736-88.
5. Ke C, Liang J, Liu M, Liu S, Wang C. Burden of chronic kidney disease and its risk-attributable burden in 137 low-and middle-income countries, 1990–2019: results from the global burden of disease study 2019. BMC Nephrology. 2022;23(1):17.
6. Foreman KJ, Marquez N, Dolgert A, Fukutaki K, Fullman N, McGaughey M, et al. Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: reference and alternative scenarios for 2016–40 for 195 countries and territories. The Lancet. 2018;392(10159):2052-90.
7. Liyanage T, Ninomiya T, Jha V, Neal B, Patrice HM, Okpechi I, et al. Worldwide access to treatment for end-stage kidney disease: a systematic review. Lancet. 2015;385(9981):1975-82.
8. Vanholder R, Annemans L, Brown E, Gansevoort R, Gout-Zwart JJ, Lameire N, et al. Reducing the costs of chronic kidney disease while delivering quality health care: a call to action. Nat Rev Nephrol. 2017;13(7):393-409.
9. Jha V, Al-Ghamdi SMG, Li G, Wu MS, Stafylas P, Retat L, et al. Global Economic Burden Associated with Chronic Kidney Disease: A Pragmatic Review of Medical Costs for the Inside CKD Research Programme. Adv Ther. 2023;40(10):4405-20.
10. Li PK, Chan GC, Chen J, Chen HC, Cheng YL, Fan SL, et al. Tackling Dialysis Burden around the World: A Global Challenge. Kidney Dis (Basel). 2021;7(3):167-75.
11. Australia and New Zealand Dialysis and Transplant Registry. ANZDATA 46th Annual Report 2023 2023 [Available from: https://www.anzdata.org.au/report/anzdata-46th-annual-report-2023-data-to-2022/.
12. Bello AK OI, Levin A, Ye F, Saad S, Zaidi D, Houston G, , Damster S AS, Abu-Alfa A, Ashuntantang G, Caskey FJ, Cho Y, , Coppo R DR, Davison S, Gaipov A, Htay H, Jindal K, Lalji R, Madero M, , Osman MA PR, See E, Shah DS, Sozio S, Suzuki Y, Tesar V, Tonelli M, , Wainstein M WM, Yeung E, Johnson DW. ISN–Global Kidney Health Atlas: A report by the International Society of Nephrology: An Assessment of Global Kidney Health Care Status focussing on Capacity, Availability, Accessibility, Affordability and Outcomes of Kidney Disease. Brussels, Belgium: International Society of Nephrology; 2023.
13. Talbot B, Davies S, Burman J, Ritchie A, Snelling P, Lynch S, et al. The Point-of-Care Peritoneal Dialysis System Early Evaluation Study (POC-PDEE): A pilot proof-of-principal study of the Ellen Medical Devices Point-of-Care affordable peritoneal dialysis system. Perit Dial Int. 2024:8968608231209850.
14. Sundström J, Bodegard J, Bollmann A, Vervloet MG, Mark PB, Karasik A, et al. Prevalence, outcomes, and cost of chronic kidney disease in a contemporary population of 2·4 million patients from 11 countries: The CaReMe CKD study. Lancet Reg Health Eur. 2022;20:100438.
15. United States Renal Data System. 2023 USRDS Annual Data Report: Epidemiology of kidney disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2023.
16. Canadian Institute for Health Information. Organ replacement in Canada: CORR annual statistics. 2023 [Available from: https://www.cihi.ca/en/organ-replacement-in-canada-corr-annual-statistics.
17. Beaudry A, Ferguson TW, Rigatto C, Tangri N, Dumanski S, Komenda P. Cost of Dialysis Therapy by Modality in Manitoba. Clin J Am Soc Nephrol. 2018;13(8):1197-203.
18. Ferguson TW, Whitlock RH, Bamforth RJ, Beaudry A, Darcel J, Di Nella M, et al. Cost-Utility of Dialysis in Canada: Hemodialysis, Peritoneal Dialysis, and Nondialysis Treatment of Kidney Failure. Kidney Medicine. 2021;3(1):20-30.e1.
19. Baigent C, Emberson J, Haynes R, Herrington WG, Judge P, Landray MJ, et al. Impact of diabetes on the effects of sodium glucose co-transporter-2 inhibitors on kidney outcomes: collaborative meta-analysis of large placebo-controlled trials. The Lancet. 2022;400(10365):1788-801.

20. Shaman AM, Bain SC, Bakris GL, Buse JB, Idorn T, Mahaffey KW, et al. Effect of the Glucagon-Like Peptide-1 Receptor Agonists Semaglutide and Liraglutide on Kidney Outcomes in Patients With Type 2 Diabetes: Pooled Analysis of SUSTAIN 6 and LEADER. Circulation. 2022;145(8):575-85.
21. Xie F, Zhang D, Wu J, Zhang Y, Yang Q, Sun X, et al. Design and implementation of the first nationwide, web-based Chinese Renal Data System (CNRDS). BMC Med Inform Decis Mak. 2012;12:11.
22. Xie Y, Chen X. Epidemiology, major outcomes, risk factors, prevention and management of chronic kidney disease in China. Am J Nephrol. 2008;28(1):1-7.
23. Wang F, Yang C, Long J, Zhao X, Tang W, Zhang D, et al. Executive summary for the 2015 Annual Data Report of the China Kidney Disease Network (CK-NET). Kidney Int. 2019;95(3):501-5.
24. Liu Y, Ning X, Zhang L, Long J, Liang R, Peng S, et al. Prevalence of long-term complications in inpatients with diabetes mellitus in China: a nationwide tertiary hospital-based study. BMJ Open Diabetes Res Care. 2022;10(3).
25. Yu X, Yang X. Peritoneal dialysis in China: meeting the challenge of chronic kidney failure. Am J Kidney Dis. 2015;65(1):147-51.
26. Yu X, Yang X, Huang N. Management of a rapidly growing peritoneal dialysis population at the First Affiliated Hospital of Sun Yat-sen University. Perit Dial Int. 2014;34 Suppl 2(Suppl 2):S31-4.
27. Chan JY, Chen YL, Yuen SK, Wong PN, Cheng HM, Mo KL, et al. The Hong Kong Renal Registry- 2022 update. Hong Kong Med J. In Press.
28. Wong CKH, Chen J, Fung SKS, Mok M, Cheng YL, Kong I, et al. Lifetime cost-effectiveness analysis of first-line dialysis modalities for patients with end-stage renal disease under peritoneal dialysis first policy. BMC Nephrol. 2020;21(1):42.
29. Wong CKH, Chen J, Fung SKS, Mok MMY, Cheng YL, Kong I, et al. Direct and indirect costs of end-stage renal disease patients in the first and second years after initiation of nocturnal home haemodialysis, hospital haemodialysis and peritoneal dialysis. Nephrol Dial Transplant. 2019;34(9):1565-76.
30. de Vries EF, Los J, de Wit GA, Hakkaart-van Roijen L. Patient, family and productivity costs of end-stage renal disease in the Netherlands; exposing non-healthcare related costs. BMC Nephrol. 2021;22(1):341.
31. Li PK-T, Lu W, Mak S-K, Boudville N, Yu X, Wu MJ, et al. Peritoneal dialysis first policy in Hong Kong for 35 years: Global impact. Nephrology. 2022;27(10):787-94.
32. Kwong VWK, Au CWY, Law MC, Chow KM, Szeto CC, Li PKT. Home haemodialysis with a novel machine in a patient with end-stage kidney disease: first case report from Asia. Hong Kong Med J. 2023;29(3):265-7.
33. Clark WR, Turk JE, Jr. The NxStage System One. Semin Dial. 2004;17(2):167-70.
34. Nardelli L, Scalamogna A, Cicero E, Castellano G. Incremental peritoneal dialysis allows to reduce the time spent for dialysis, glucose exposure, economic cost, plastic waste and water consumption. J Nephrol. 2023;36(2):263-73.
35. 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 Health. 2007;10(1):61-72.
36. Zahirian Moghadam T, Powell J, Sharghi A, Zandian H. Economic evaluation of dialysis and comprehensive conservative care for chronic kidney disease using the ICECAP-O and EQ-5D-5L; a comparison of evaluation instruments. Cost Eff Resour Alloc. 2023;21(1):81.
37. Bavanandan S, Hooi LS, Ong LM, Choo CL. Chapter 1: All Kidney Replacement Therapy in Malaysia. 30th Report of the Malaysian Dialysis and Transplant Registry: The National Renal Registry, Malaysian Society of Nephrology; 2022 [Available from: https://www.msn.org.my/nrr/30th-report-of-the-malaysian-dialysis-and-transplant-registry-2022/.
38. Ong LM, Bavanandan S, Hooi LS, Choo CL. Chapter 2: Dialysis in Malaysia. 30th Report of the Malaysian Dialysis and Transplant Registry: The National Renal Registry, Malaysian Society of Nephrology; 2022 [Available from: https://www.msn.org.my/nrr/30th-report-of-the-malaysian-dialysis-and-transplant-registry-2022/.
39. Surendra NK, Abdul Manaf MR, Hooi LS, Bavanandan S, Mohamad Nor FS, Shah Firdaus Khan S, et al. Health related quality of life of dialysis patients in Malaysia: Haemodialysis versus continuous ambulatory peritoneal dialysis. BMC Nephrol. 2019;20(1):151.
40. Surendra NK, Abdul Manaf MR, Hooi LS, Bavanandan S, Mohamad Nor FS, Firdaus Khan SS, et al. Cost utility analysis of end stage renal disease treatment in Ministry of Health dialysis centres, Malaysia: Hemodialysis versus continuous ambulatory peritoneal dialysis. PLoS One. 2019;14(10):e0218422.

41. Mak WY, Leong CT, Ong LM, Bavanandan S, Mushahar L, Goh BL, et al. Clinical effectiveness of a Malaysian-manufactured CAPD product: A randomised trial. Perit Dial Int. 2021;41(3):273-83.
42. Lim SK, Goh BL, Visvanathan R, Kim SH, Jeon JS, Kim SG, et al. A multicentre, multi-national, double-blind, randomised, active-controlled, parallel-group clinical study to assess the safety and efficacy of PDA10 (Epoetin-alpha) vs. Eprex® in patients with anaemia of chronic renal failure. BMC Nephrol. 2021;22(1):391.
43. Ismail H, Abdul Manaf MR, Abdul Gafor AH, Mohamad Zaher ZM, Ibrahim AIN. Economic Burden of ESRD to the Malaysian Health Care System. Kidney International Reports. 2019;4(9):1261-70.
44. Singapore Renal Registry Report 2021: National Registry of Diseases Office; 2022 [Available from: https://www.nrdo.gov.sg/.
45. Tan WB, Szücs A, Burkill SM, Hui OS, Young D, Hoon GL. Nephrologist referrals of older patients with chronic kidney disease in Singapore: a cross-sectional study. BJGP Open. 2022;6(3).
46. Chua YT, Leo CH, Chua HR, Wong WK, Chan GC, Vathsala A, et al. Disparities in ethnicity and metabolic disease burden in referrals to nephrology. Singapore Med J. 2023.
47. Health Promotion Board. Measures for Nutri-Grade Beverages. 2022 [Available from: https://hpb.gov.sg/healthy-living/food-beverage/nutri-grade.
48. Lee LY. S'pore to study regulatory measures to reduce sodium in food: Ong Ye Kung. The Straits Times [Internet]. 2023 December 30, 2023. Available from: https://www.straitstimes.com/singapore/s-pore-to-study-regulatory-measures-to-reduce-sodium-in-food-ong-ye-kung.
49. Ministry of Health. Singapore. Healthier SG Program 2024 [Available from: https://www.healthiersg.gov.sg/.
50. Lee CC, Hsu CC, Lin MH, Chen KH, Wu IW. Hospitalization in patients with dialysis in Taiwan: A nationwide population-based observational study. J Formos Med Assoc. 2022;121 Suppl 1:S39-s46.
51. Lin M-Y, Chiu Y-W, Hsu Y-H, Wu M-S, Chang J-M, Hsu C-C, et al. CKD Care Programs and Incident Kidney Failure: A Study of a National Disease Management Program in Taiwan. Kidney Medicine. 2022;4(7):100485.
52. Wu M-Y, Wu M-S. Taiwan renal care system: A learning health-care system. Nephrology. 2018;23(S4):112-5.
53. Kidney Research UK. Kidney disease: A UK public health emergency 2023. Available from: https://www.kidneyresearchuk.org/wp-content/uploads/2023/06/Economics-of-Kidney-Disease-full-report_accessible.pdf
54. UK Renal Registry. UK Renal Registry 25th Annual Report 2023 [Available from: https://ukkidney.org/audit-research/annual-report/25th-annual-report-data-31122021.
55. Lipkin G, McKane W. Renal Medicine. GIRFT Programme National Specialty Report: National Health Service; 2021. Available from: https://gettingitrightfirsttime.co.uk/wp-content/uploads/2021/09/Renal-Medicine-Sept21k.pdf.
56. Burt HE, Brown MK, He FJ, MacGregor GA. Salt: the forgotten foe in UK public health policy. BMJ. 2022;377:e070686.
57. Dreyer G, Hull S, Mathur R, Chesser A, Yaqoob MM. Progression of chronic kidney disease in a multi-ethnic community cohort of patients with diabetes mellitus. Diabet Med. 2013;30(8):956-63.
58. Qiao Y, Shin JI, Chen TK, Sang Y, Coresh J, Vassalotti JA, et al. Association of Albuminuria Levels With the Prescription of Renin-Angiotensin System Blockade. Hypertension. 2020;76(6):1762-8.
59. van Mil D, Kieneker LM, Evers-Roeten B, Thelen MHM, de Vries H, Hemmelder MH, et al. Participation rate and yield of two home-based screening methods to detect increased albuminuria in the general population in the Netherlands (THOMAS): a prospective, randomised, open-label implementation study. Lancet. 2023;402(10407):1052-64.
60. Sloan CE, Coffman CJ, Sanders LL, Maciejewski ML, Lee S-YD, Hirth RA, et al. Trends in Peritoneal Dialysis Use in the United States after Medicare Payment Reform. Clinical Journal of the American Society of Nephrology. 2019;14(12):1763-72.
61. Reifsnider OS, Kansal AR, Wanner C, Pfarr E, Koitka-Weber A, Brand SB, et al. Cost-Effectiveness of Empagliflozin in Patients With Diabetic Kidney Disease in the United States: Findings Based on the EMPA-REG OUTCOME Trial. Am J Kidney Dis. 2022;79(6):796-806.
62. Kaplan JM, Niu J, Ho V, Winkelmayer WC, Erickson KF. A Comparison of US Medicare Expenditures for Hemodialysis and Peritoneal Dialysis. J Am Soc Nephrol. 2022;33(11):2059-70.
63. Quinn RR, Lam NN, Ravani P, Oliver MJ, Blake PG, Tonelli M. The Advancing American Kidney Health Initiative: The Challenge of Measuring Success. J Am Soc Nephrol. 2022;33(6):1060-2.

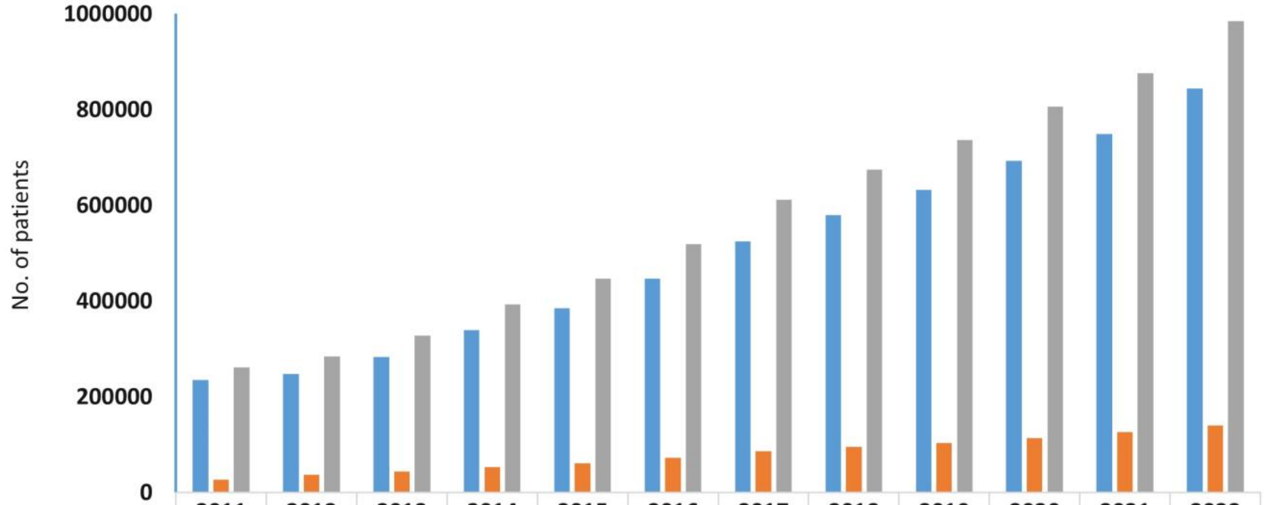
64. Li PK-T, Garcia-Garcia G, Lui S-F, Andreoli S, Fung WW-S, Hradsky A, et al. Kidney health for everyone everywhere: from prevention to detection and equitable access to care. Kidney International. 2020;97(2):226-32.
65. Chan GC, Kalantar-Zadeh K, Ng JK, Tian N, Burns A, Chow KM, et al. Frailty in Patients on Dialysis. Kidney Int. 2024 May 3:S0085-2538(24)00315-6.

Figure Legends

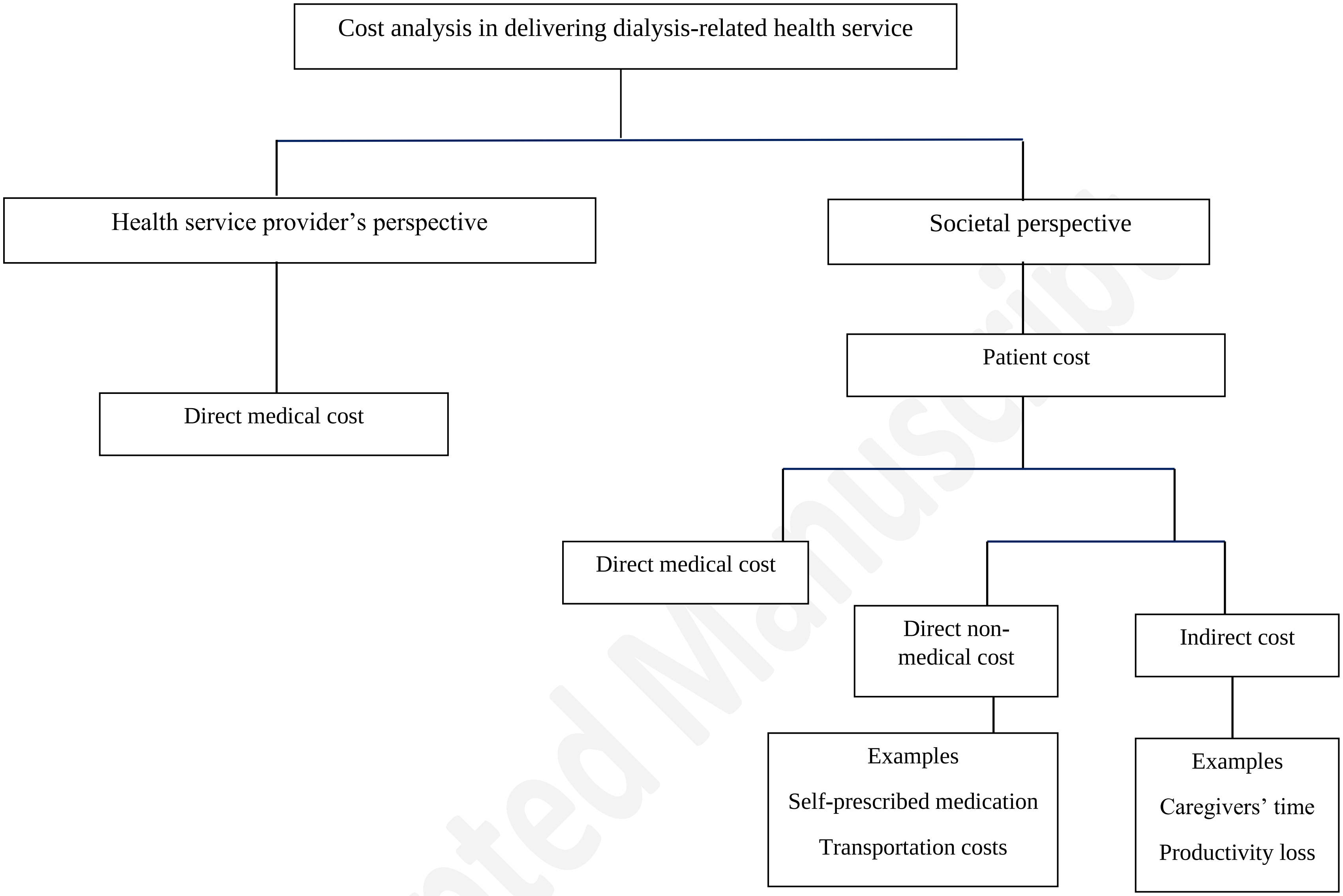
Figure 1. **Rising number of prevalent dialysis patients in China from 2011-2022. In 2022, there are 140,544 PD patients in China, which accounted for 14.2% of total dialysis population** (data source: Chinese National Renal Data System)**.** HD, hemodialysis; PD, peritoneal dialysis

Figure 2. **A framework to delineate cost analysis from both the health service provider's perspective and the societal perspective.**

Figure 3. **Prevalent cases of kidney replacement therapy patients in UK 2011-2021** (data source: UK renal registry [54]). HHD, home hemodialysis; ICHD, in-center hemodialysis; KRT, kidney replacement therapy; PD, peritoneal dialysis; Tx, kidney transplant



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
HD	234632	248016	283581	339748	385055	447435	524467	579381	632653	692736	749573	844265
PD	27245	36605	44386	53211	61583	72149	86865	94896	103348	114023	126392	140544
Total	261877	284621	327967	392959	446638	519584	611332	674277	736001	806759	875965	984809


Cost analysis in delivering dialysis-related health service
Health service provider's perspective
Societal perspective
Patient cost
Direct medical cost
Direct medical cost
Direct non-medical cost
Indirect cost
Examples
Self-prescribed medication
Transportation costs
Examples
Caregivers' time
Productivity loss

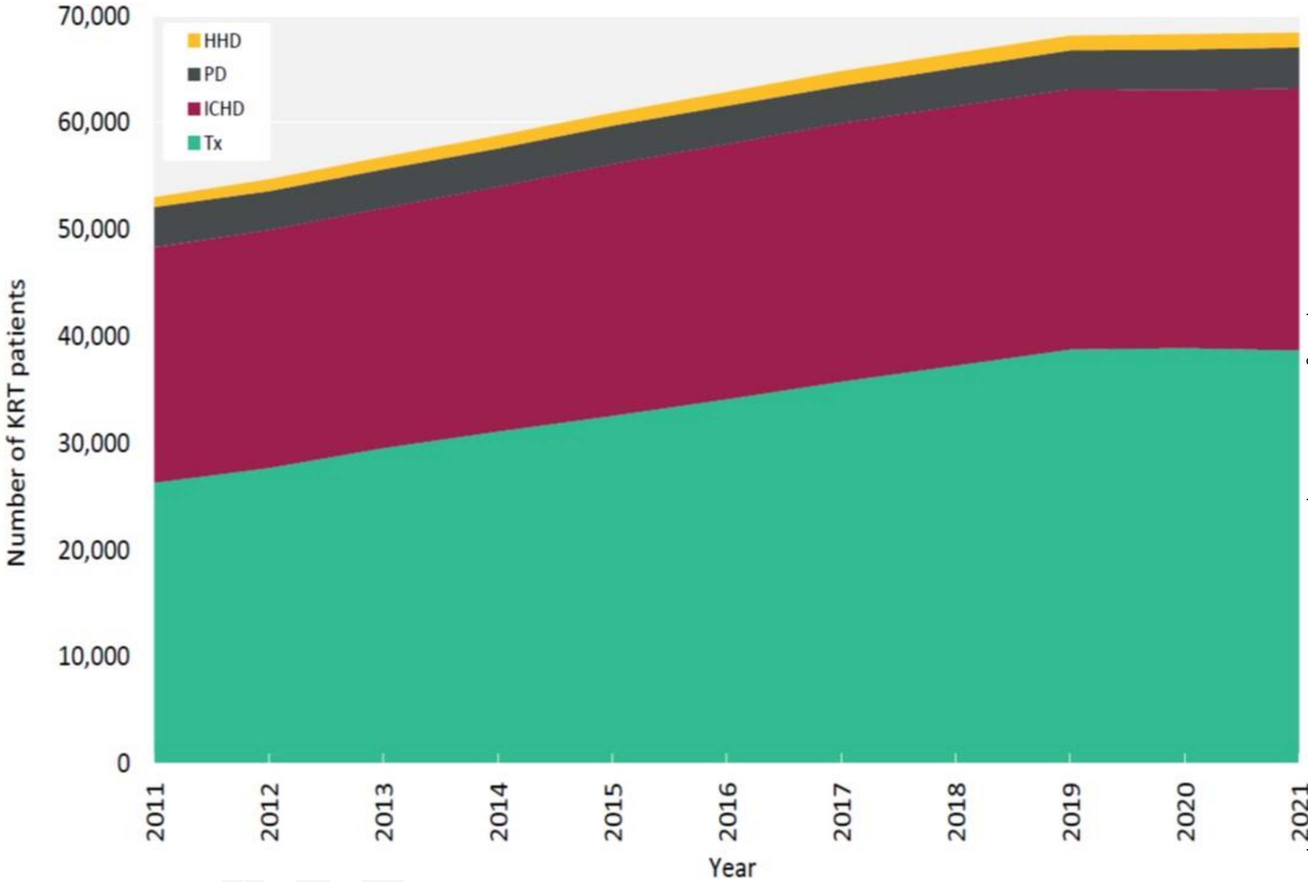

HHD
PD
ICHD
Tx
Number of KRT patients
Year
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

Table 1. The incidence and prevalence of patients with ESKD, and the major funding model for dialysis of the 10 countries/regions participating in the 4th International Congress of Chinese Nephrologists

Country/Region	Incidence of treated ESKD (pmp)	Prevalence of treated ESKD (pmp)	Major funding model for dialysis
Australia	127	1109	Publicly funded and free at the point of delivery
Canada	206	1426	Publicly funded and free at the point of delivery
China	127	621	Multiple systems (programs provided by government, NGO and communities)
Hong Kong	198	1506	Multiple systems (programs provided by government, private, charities)
Malaysia	280	1584	Multiple systems (programs provided by government, NGO and communities)
New Zealand	133	1061	Publicly funded and free at the point of delivery
Singapore	380	2577	Multiple systems (programs provided by government, private, charities)
Taiwan	522	3839	Publicly funded and free at the point of delivery
UK	123	1041	Publicly funded and free at the point of delivery
US	410	2436	Mix of publicly funded and private systems

The incidence and prevalence of treated ESKD patients in 2021 were based on the estimation by USRDS 2023 Annual Data Report (15) and 46th Annual ANZDATA Report (11) respectively. The nature of major funding models were based on the opinion of the experts from participating countries/regions in the present conference.

Table 2. Challenges arising from the global burden of CKD and potential solutions to alleviate the economic impact.

Challenges	Potential solutions
Rising number of ESKD patients worldwide that require KRT	• Prioritizing the utilization of home-based dialysis therapy (PD and home HD) as they are more cost-effective • Establishing national or regional dialysis registry which can better quantify disease and economic burden • Promoting kidney transplant
Aging dialysis patients who have more comorbidities and greater susceptibilities to complications	• Consideration of conservative kidney management before initiation of KRT, or discussion of advance care planning (including dialysis withdrawal) in selected elderly patients on KRT, based on shared decision-making with patients and their family • Implementation of multi-disciplinary care program in advanced CKD patients to ensure smooth transition to KRT
Increasing cost of dialysis consumables	• Local manufacture of PD system or solution • Consideration of incremental dialysis in incident patients with RKF • Increase government funding or reimbursement for KRT (with funding priority to facilities who are willing to build up home dialysis program)
Increasing prevalence of diabetes (a leading cause of ESKD especially in high-income and high-middle income countries)	• Early and regular screening of eGFR and albuminuria in patients with diabetes • Optimization of pre-ESKD management according to clinical guideline to slow down progression to ESKD • Timely initiation of effective treatment options such as SGLT-2 inhibitors (which provide cardio-renal protection for CKD patients)

Abbreviations: CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; ESKD, end stage kidney disease; HD, hemodialysis; KRT, kidney replacement therapy; PD, peritoneal dialysis; RKF, residual kidney function; SGLT-2 inhibitors, sodium-glucose cotransporter-2 inhibitors