COMMENTARY

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Health economics of kidney replacement therapy in Singapore: Taking stock and looking ahead

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ABSTRACT

The prevalence of end-stage kidney disease (ESKD) in Singapore remains high and continues to rise. We continue to face major challenges in containing the rising incidence of ESKD and providing sustainable kidney replacement therapy. Our cost projections provide an insight into the present and future, urging a call to action to augment existing initiatives to address the emergent issues.

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Burden of ESKD in Singapore. The incidence of chronic kidney disease (CKD) stage 5 in Singapore increased by 31% from 383.9 per million population (pmp) in 2010 to 503 pmp in 2018. The prevalence of patients with end-stage kidney disease (ESKD) on dialysis increased by 58% from 1,218 pmp in 2010 to 1,925.9 pmp in 2019. This is attributed to the high prevalence of diabetes mellitus and an ageing population. Diabetes remains the leading cause of ESKD in new patients starting dialysis, accounting for 68.2% of cases in 2019.[1]

With diabetes on the rise, it is estimated that 1 in 2 Singaporeans will have type 2 diabetes by 2050,[2] which will have a ripple effect on the burden of CKD and ESKD. There are currently no available registry data capturing the number of CKD patients and its related costs. Based on a prior projection of CKD patients in Singapore, there are about 400,000 CKD patients in 2021, translating to an estimated cost of SGD1.35 billion annually.[3] Another study reported mean annual costs for patients with type 2 diabetes who had CKD to be SGD3,385 annually, which was 2.2 times higher than that for diabetic patients without CKD.[4]

Low kidney transplant rates. Kidney transplant rates have remained stagnant over the last decade, in stark contrast to the increasing rate of ESKD in Singapore. In 2019, living donors contributed to 54% of all transplants done locally, while deceased donors contributed 33%.[1] Despite a steady increase in the number of living donor kidney transplants over the years, the increase is unable to meet demand. While the introduction of the Human Organ Transplant Act legislation in 1987 and its subsequent amendment in 2004 led to initial increases in deceased donor transplants, the rate of transplantation at 24.8 pmp in 2019 remained well short of demand; in 2020 the average waiting time for a deceased donor kidney transplant was 9.3 years.[5]

Dialysis modalities in Singapore. Dialysis modalities in Singapore include haemodialysis (HD) that is typically done in-centre, and peritoneal dialysis (PD) that is home-based. There are a small number of patients on home HD in Singapore, but this is limited due to various reasons. PD is the primary established home-based dialysis in Singapore.

A recent meta-analysis suggested that PD and in-centre HD carry equivalent survival benefits, where reported differences in survival between treatments largely reflect a combination of factors unrelated to clinical efficacy.[6] PD therapy has benefits such as preservation of residual kidney function, better survival in the initial period of dialysis therapy[7] and improved quality of life.[8]

In Singapore, however, the survival of PD patients has remained inferior to HD, although progress has been made over the past 10 years. Multiple factors contribute to inferior PD outcomes, including: patient selection bias; older, frail patients; patients with contraindications for HD who are initiated on PD; lack of PD clinical outcome key performance indicators (KPIs) such as anaemia,

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bone disease and Kt/V at a programme level; absence of national registry of PD KPIs such as peritonitis and exit site infections; and insufficient manpower and clinical governance to support PD in the community.

In 2019, there were 128 dialysis centres in Singapore. In order to keep up with the growing need for HD, there needs to be an increase to 748 dialysis centres by 2035.[3] As a country with limited land resources, building more dialysis centres is not sustainable or cost-effective. In addition, guidelines from the Ministry of Health (MOH), Singapore, mandates a nurse to patient ratio of 1:5 for HD, which is a greater manpower requirement compared to 1:20 for PD.[9] The growing need for HD will create a major strain on nursing manpower. Despite target-setting by MOH previously, increase of subsidies and educational efforts by the government, PD penetration has remained under 14% from 2010 to 2019.[1]

Growing healthcare expenditures and COVID-19 pandemic—a new reality. At a recent MOH work plan seminar headed by Singapore's health minister, it was reported that Singapore's healthcare expenditure had doubled from SGD10 billion in 2010 to SGD21 billion in 2018. This will almost be tripled to SGD59 billion by 2030. The exponential rise has been made worse by the COVID-19 pandemic.

Kidney Disease: Improving Global Outcomes (KDIGO) 2012 guidelines indicated that the costs of dialysis and transplantation consume disproportionate amounts within healthcare budgets worldwide.[10] Dialysis costs for 2021 were estimated to be about SGD300 million. This is 2% of the MOH non-COVID-19-related annual budget (SGD14.4 billion),[11] being consumed by 1.38% (7,754 prevalent patients on dialysis in 2019) of the population. The actual financial burden of CKD is difficult to assess without a national CKD registry that captures the number of patients by CKD stage.

Currently, many measures remain in place to control the spread of COVID-19. ESKD patients are at higher risk of severe illness due to their compromised immune system and high comorbidity burden. Dialysis clinics and hospitals have adopted telehealth to continue care provision without having in-person visits.[12] Recent data have also suggested that home-based dialysis has a protective effect over centre-based haemodialysis, with an approximate 3-fold reduction in the risk of infections.[13]

With the added burden of COVID-19-related healthcare costs, it has become more pressing to find a sustainable model of kidney replacement therapy provision and financing. To examine costs associated with in-centre HD and home PD and its economic impact, we ran cost simulations using data from existing literature.

Cost simulation for in-centre HD and home PD. We ran simulations over different timelines to reach a 40% PD penetration nationally. This target was set by the government previously, to increase the proportion of patients on continuous ambulatory PD to 40% by 2010.[14] The incident number of PD initiations needed was estimated based on 10-year median changes in incidence and prevalence of definitive PD numbers, as reported by the national registry.[1] Subsequent real-time dropout rates captured in a PD registry would reflect actual PD uptake more accurately for estimation of numbers required to maintain and/or increase PD prevalence in Singapore.

We first projected a gradual 2–4% increase in incident PD numbers annually, to increase PD penetration from the current 14% to 40% by 2029. Based on the historical growth rate of 5.4% in prevalence number of definitive dialysis,[1] we projected that there would be 13,120 patients requiring dialysis in 2029. In order to reach the target of 40% PD penetration, a gradual increase to at least 7 out of 10 patients who would ever start dialysis to initiate PD therapy is required. Of note, although the numbers required were high, once the deficit is overcome, only 2–3 out of 10 patients were needed to initiate PD to maintain a 40% PD prevalence (Table 1).

We highlight that given the mere 3.5% increment in incident uptake of PD in our dialysis population over the past 10 years,[1] unless there is an urgent push to increase PD uptake dramatically, it would take more than 10 decades to increase the incident initiations by 40% to reach the desired PD prevalence.

We ran a second projection with an accelerated increase to 40% PD penetration in the next 5 years, considering the rapid rise of patients needing dialysis and its associated healthcare costs (Table 2). To reach the target by 2026, at least 7 in 10 patients who would ever start dialysis need to initiate PD over the next 4 years. Again, the target would become more manageable once the deficit is recovered. To achieve the target of 65–75% incident PD numbers in the coming years, it would require concerted efforts from the nephrology community and the government. We can also learn from the sustained success of the PD programme in Hong Kong, where its PD-first policy has >70% of their dialysis population treated with PD.[7,15]

We next looked at the cost savings if a 40% PD penetration nationally is achieved by 2026 (Table 3). Associated costs were referenced mostly from the

Table 1. Forecast of incident peritoneal dialysis initiations needed to reach target of 40% PD penetration by 2029[1]

	2021	2022	2023	2024	2025	2026	2027	2028	2029
Prevalent number of definitive dialysis[a]	8,614	9,079	9,569	10,086	10,631	11,205	11,810	12,448	13,120
Target PD penetration, %	14.0	15.9	18.3	21.2	24.5	28.0	31.8	35.8	40.0
Target number of definitive PD	1,206	1,444	1,751	2,138	2,605	3,137	3,756	4,456	5,248
Target increase in number of definitive PD	238	307	387	467	532	619	700	792	283
Incident number of definitive PD needed[b]	680	877	1,106	1,334	1,520	1,769	2,000	2,263	809
Incident number of PD initiations needed[c]	414	534	674	813	926	1,078	1,219	1,379	493
Incident number of ever-started dialysis[d]	1,472	1,538	1,608	1,680	1,755	1,834	1,917	2,003	2,093
Incident PD initiations needed, %	28.0	34.7	41.9	48.4	52.8	58.8	63.6	68.8	**23.6**

PD: peritoneal dialysis

[a] Projection based on 10-year average 5.4% annual growth rate, calculated from Singapore Renal Registry Annual Report 2019

[b] Estimation based on 10-year median of 65% annual dropout rate of prevalent definitive PD, calculated from Singapore Renal Registry Annual Report 2019

[c] Estimation based on 10-year median of 64.1% annual gain in incident definitive PD numbers from ever starting PD, calculated from Singapore Renal Registry Annual Report 2019

[d] Projection based on 10-year median of 4.5% annual growth of number of ever-started dialysis, calculated from Singapore Renal Registry Annual Report 2019

[1] National Registry of Diseases Office. Singapore Renal Registry Annual Report 2019, 30 July 2021. Available at: https://www.nrdo.gov.sg/docs/librariesprovider3/default-document-library/srr-annual-report-2019.pdf?sfvrsn=8822fcf8_0. Accessed on 13 December 2021.

Table 2. Accelerated forecast of incident PD initiations needed to reach target of 40% PD penetration by 2026[1]

	2021	2022	2023	2024	2025	2026	2027
Prevalent number of definitive dialysis[a]	8,614	9,079	9,569	10,086	10,631	11,205	11,810
Target PD penetration, %	14.0 (current)	20.0	25.0	30.0	35.0	40.0	40.0
Target number of definitive PD	1,206	1,816	2,392	3,026	3,721	4,482	4,724
Target increase in number of definitive PD	610	576	634	695	761	242	Not applicable
Incident number of definitive PD needed[b]		1,646	1,811	1,986	2,174	691	
Incident number of PD initiations needed[c]		1,003	1,104	1,210	1,325	421	
Incident number of ever-started dialysis[d]		1,538	1,608	1,680	1,755	1,834	
Incident PD initiations needed, %		65.2	68.7	72.0	75.5	**23.0**	

PD: peritoneal dialysis

[a] Projection based on 10-year average of 5.4% annual growth rate, calculated from Singapore Renal Registry Annual Report 2019

[b] Estimation based on 10-year median of 65% annual dropout rate of prevalent definitive PD, calculated from Singapore Renal Registry Annual Report 2019

[c] Estimation based on 10-year median of 64.1% annual gain in incident definitive PD numbers from ever starting PD, calculated from Singapore Renal Registry Annual Report 2019

[d] Projection based on 10-year median of 4.5% annual growth of incident number of ever-started dialysis, calculated from Singapore Renal Registry Annual Report 2019

[1] National Registry of Diseases Office. Singapore Renal Registry Annual Report 2019, 30 July 2021. Available at: https://www.nrdo.gov.sg/docs/librariesprovider3/default-document-library/srr-annual-report-2019.pdf?sfvrsn=8822fcf8_0. Accessed on 13 December 2021.

Table 3. Projected healthcare costs and savings if target of 40% PD penetration is achieved by 2026

	Current, 2021		Future, 2026 (Status quo)		Future, 2026 (40% PD)	
	PD	HD	PD	HD	PD	HD
Percentage prevalence, %	14	86	14	86	40	60
Number of patients	1,206	7,408	1,569	9,636	4,482	6,723
Treatment costs, SGD						
APD (74% of all PD)/ month[a]	1,600		1,600		1,600	
CAPD (26% of all PD)/month[a]	1,200		1,200		1,200	
HD/month[b]		2,500		2,500		2,500
Annual treatment cost	21,648,000	222,240,000	28,166,400	289,080,000	80,462,400	201,690,000
Other associated costs per annum, SGD[15]						
Other PD costs[c]	28,706,177		37,346,593		106,684,150	
PD home visits[d]	30,330		148,667		226,210	
PD training[d]	387,550		1,899,630		2,890,467	
Other HD costs[c]		237,207,864		308,549,538		215,273,822
Total healthcare costs per annum		510,219,921		665,190,828		607,227,048
Cost savings per annum				57,963,780		

APD: automated peritoneal dialysis; CAPD: continuous ambulatory peritoneal dialysis; HD: haemodialysis; PD: peritoneal dialysis
[a] Proportion of APD and CAPD patients, estimated treatment costs based on data from Baxter Heathcare (Asia)
[b] HD treatment cost estimation based on data from The National Kidney Foundation Singapore
[c] Includes other medical costs for set-up (one-time), drugs, laboratory tests, outpatient visits, hospitalisation, death (one-time), and non-medical costs such as transportation and loss of productivity
[d] Cost estimation based on data from Baxter Healthcare (Asia) from May 2020 to April 2021
[15] Li PK, Chow KM. Peritoneal dialysis-first policy made successful: perspectives and actions. Am J Kidney Dis 2013;62:993-1005.

study by Yang et al.[16] We projected that a 40% PD prevalence would bring approximately SGD58 million per annum in cost savings, compared to remaining at 14% PD prevalence.

We then simulated the nursing manpower[9] needed to reach the target of 40% PD penetration (Table 4). By achieving 40% PD prevalence nationally, nursing manpower needed to care for patients on dialysis will be reduced by about 22%.

Lastly, we looked at infrastructure savings. Based on data from The National Kidney Foundation Singapore, a HD centre with 20 stations and space to house a central water treatment system costs approximately SGD2 million to build. In contrast, a PD clinic costs under SGD20,000. If the current dialysis landscape persists, there will be an additional 2,000 patients on HD by 2026. This will require 100 more 20-station HD centres to meet the demand, costing SGD200 million in infrastructure costs alone.

The need for transformative strategies. Based on our cost simulations, the rising healthcare costs will not be sustainable in the long term. Better utilisation of healthcare budgets to provide quality and affordable care for patients with kidney disease is needed. We propose the following strategies:

(1) **Halting the CKD wave** via intensified national movements to concentrate efforts on prevention, early screening and detection of diabetes and hypertension especially in high-risk groups, empowering primary care providers with adequate resources to manage chronic diseases, and encouraging early referrals for specialist management.

(2) **Advocating cost-effective home PD** via early discussion of treatment options, expansion of patient education programmes, increasing support for a community shared-care model by multidisciplinary care teams with assisted and respite care services, revision of subsidy structure and strengthening the support for PD healthcare professionals in terms of funding, infrastructure, and manpower.

(3) **Developing strategies to increase organ donation** such as establishing quality improvement programmes where healthcare professionals are responsible for improving processes to increase rates of donor

Table 4. Nursing manpower required to manage increase of PD prevalence to 40%

	2021	2026 (Status quo)	2026 (40% PD)
Total number of dialysis patients[a]	8,614	11,205	11,205
Patients on PD, no. (%)	1,206 (14)	1,569 (14)	4,482 (40)
Patients on HD, no. (%)	7,408 (86)	9,636 (86)	6,723 (60)
Nurses needed	60	78	224
For PD (1:20 nurse to patient ratio)	1,482	1,927	1,345
For HD (1:5 nurse to patient ratio)	1,542	2,005	1,569
Total number			
Reduction in nursing manpower needs, no. (%)		436 (21.7)	

HD: haemodialysis; PD: peritoneal dialysis
[a] Projection based on 10-year average of 5.4% annual growth rate, calculated from Singapore Renal Registry Annual Report 2019

actualisation and donation after circulatory death. Strategies are needed to address socio-cultural anxieties as well as professional and societal vulnerabilities which contribute to the barriers and ethical quandaries in living kidney donation.[17]

In conclusion, the expanding burden of kidney failure is a major public health problem worldwide. It is critical that we continue to search for more cost-effective ways to provide kidney replacement therapy. While PD could be a sustainable treatment model, more health economics studies are warranted for further evaluation. Concurrently, we must look at long-term solutions for CKD prevention and reducing CKD progression to ESKD, as well as increasing kidney transplant rates.

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