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Commentary

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Diabetic Kidney Disease in Brunei Darussalam – A Healthcare Cost Tsunami in the Making

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End stage kidney disease in Brunei Darussalam

End Stage Kidney Disease (ESKD) is a global non-communicable disease (NCD) phenomenon that has gained momentous traction in the past few decades. Increasing global urbanisation, along with the rising prevalence of diabetes mellitus (DM), hypertension (HT), and obesity, has fueled the need for greater investments in improving dialysis access and care for ESRD patients. The World Health Organisation (WHO) has formally prioritised kidney health within the NCD disease agenda in May 2025 at the World Health Assembly in Geneva[1], after years of dedicated lobbying by the nephrology community. This milestone is a recognition of the epidemic of chronic kidney disease (CKD) and the inevitable healthcare cost tsunami that will overwhelm vulnerable countries. This paradigm shift will also pave the way for earlier detection, better prevention and stronger health systems to align with the United Nation's Sustainable Development Goals of reducing premature mortality from NCD (Goal 3.4) and universal health coverage (Goal 3.8).[2]

Brunei Darussalam has undertaken commendable measures to address the threat of NCD, under the overarching *Mulitisectoral Action Plan for the Prevention and Control of Noncommunicable Disease* (BruMAP-NCD 2021-2025).[3] However, the current roadmap and framework lack specific strategic objectives on renal health, which may reflect an underestimation of the significance of ESKD within the broader context. Over the past decade, the number of patients with ESKD in Brunei has risen dramatically. According to data from the Brunei Dialysis and Transplant Registry (BDTR), the incidence and prevalence rates reached 574 and 2,244 per million population (pmp) respectively in 2023.[4] By the end of 2024, the total number of ESKD patients was 1,085, corresponding with an average annual growth rate of 5% over the previous ten years. This translates to approximately one ESKD patient for every 420 residents in the country in 2024. Notably, the annual increase in ESKD cases (5%) has far outpaced the national population growth rate of 1.4% over the same period.[5] Haemodialysis (HD)

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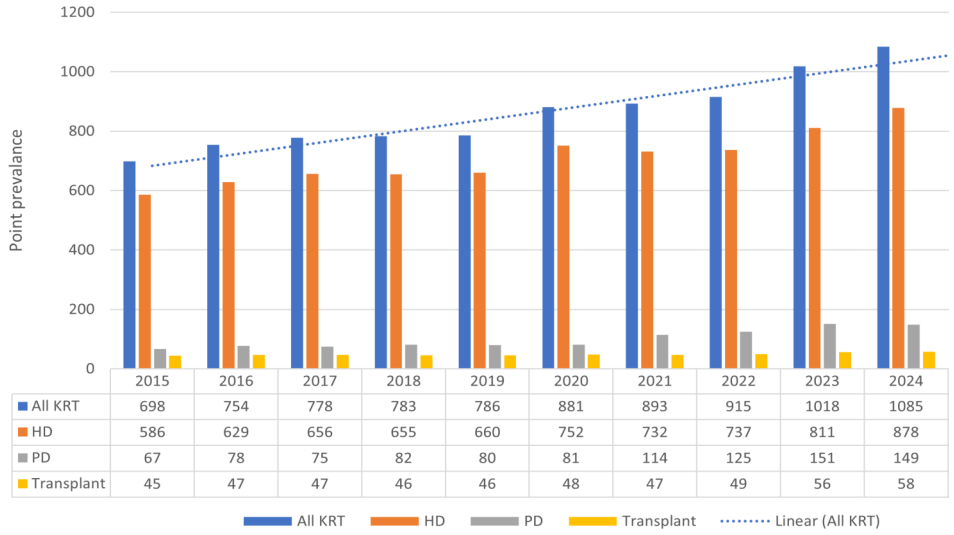
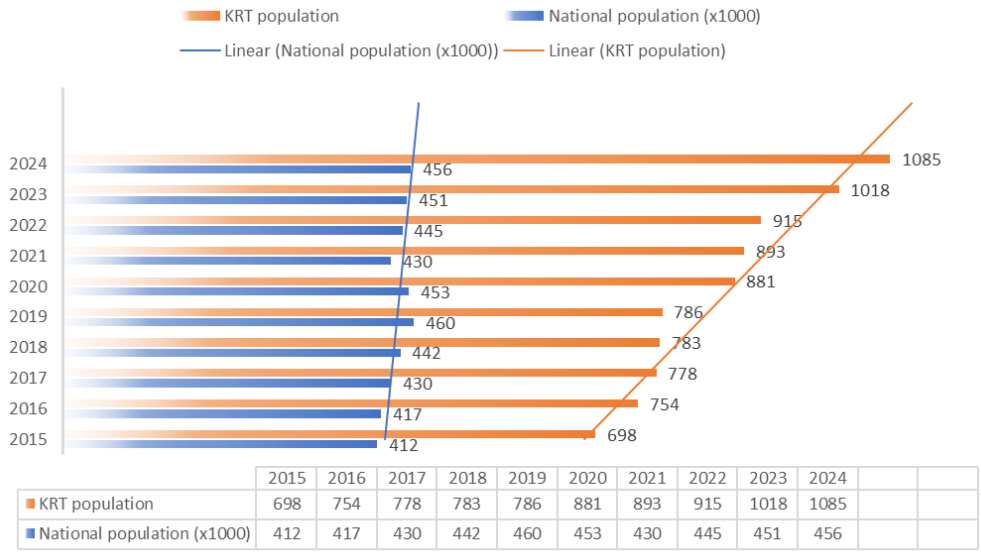


	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
All KRT	698	754	778	783	786	881	893	915	1018	1085
HD	586	629	656	655	660	752	732	737	811	878
PD	67	78	75	82	80	81	114	125	151	149
Transplant	45	47	47	46	46	48	47	49	56	58

Figure 1: ESKD population (point prevalence) in Brunei from 2015-2024 (adopted from the BDTR – a national database that records demographic and clinical data pertaining to ESKD in Brunei).

remains the predominant kidney replacement therapy (KRT), comprising 81% of patients, while peritoneal dialysis (PD) and kidney transplantation account for 14% and 5%, respectively. **Figure 1** illustrates the number of patients undergoing KRT, HD, PD, and transplantation from 2015 to 2024, and **Figure 2** highlights the disproportionate growth of both the national population and the ESKD population over the last decade.

International comparison through the United States Renal Data System (USRDS) consistently ranked Brunei amongst the top five countries in the world for prevalence and incidence rates of ESKD.[6] Developing countries, like Brunei, have shown accelerated growth of ESKD patients over the past decade, likely through the effects of globalisation and impact from NCD.[7] However, rates for most developed countries in the West have plateaued over the past decade with some countries even showing reduction in ESKD prevalence and incidence in recent years.[7] The stabilisation of rates in developed countries also coincided with greater population awareness of NCD and better policy implementations and adoption of NCD policies.[8] As a result, strategic adoption and application of research-grounded



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
KRT population	698	754	778	783	786	881	893	915	1018	1085
National population (x1000)	412	417	430	442	460	453	430	445	451	456

Figure 2: Disproportionate increment in national and ESKD population in the last decade (adopted from the BDTR).

policies are urgently needed to address an impeding healthcare cost tsunami in Brunei.

Diabetic kidney disease in Brunei Darussalam

DM is the most common cause of CKD in the world.[9] The burden of diabetic kidney disease (DKD) has snowballed in the past few decades, and is the main driver for the exponential growth of the ESKD population.[9] Brunei has an extremely high burden of DKD, consistently attributing to over 70% of incident ESKD patients in the country over the past decade.[4] The country has world leading rates of DM-related ESKD incidence (370 pmp) and DM-ESKD % (73%) in 2021.[6] Data from the 2023 BDTR showed even more concerning numbers showing a rise in the DM-related ESKD incidence to 453 pmp and DM- ESKD % to 79%,[4] potentially solidifying Brunei's position as the most severely affected country in the, as yet unpublished, 2023 USRDS global ranking. **Figures 3 and 4** showed the current DM-ESKD % and DM-related incident rates compared to other countries.

Data from the USRDS also showed that in 2021, Singapore and Malaysia had notable DM-ESKD % of 66% and 53%, respectively, though these figures remained lower than Brunei's.[6] Regionally, other lower-income South East Asian (SEA) countries such as Vietnam, Thailand, and Indonesia have also been disproportionately impacted by high rates of DM-related ESKD.[10] When compared internationally, the DM-ESKD % in SEA countries far exceed those in wealthier regions, including Europe (12%), the United Kingdom (25%), Australia (35%), the United States (47%), East Asia (43-49%), and the Middle East (47-64%).[6] Interestingly, the prevalence of DM-ESKD in Brunei and across SEA countries appears to be unrelated to either national diabetes prevalence or socio-economic status[10], indicating influences from unique environmental and genetic factors.

The epidemiological triad of genetics, behaviour and environment

Genetics may play a role in the evolution of DKD, with both clinical and epidemiological studies demonstrating familial aggregation in different ethnic groups.[11] Many studies have been done to elucidate the role of genetic variants in DKD susceptibility, but results are not replicable and inconsistent despite using genome-wide association studies in different countries with different ethnic groups.[12] Many genetic polymorphisms linked to specific gene loci have been shown to be associated with DKD, the biological significance of these findings remains unclear without comprehensive haplotype analysis and functional validation.[13] For instance, functional studies exploring gene expression and epigenetic regulation, such as expression quantitative trait loci (eQTL) mapping, are essential to determine how these variants contribute to DKD pathophysiology.

A Chinese study by Jiang *et al.* in 2020 showed that

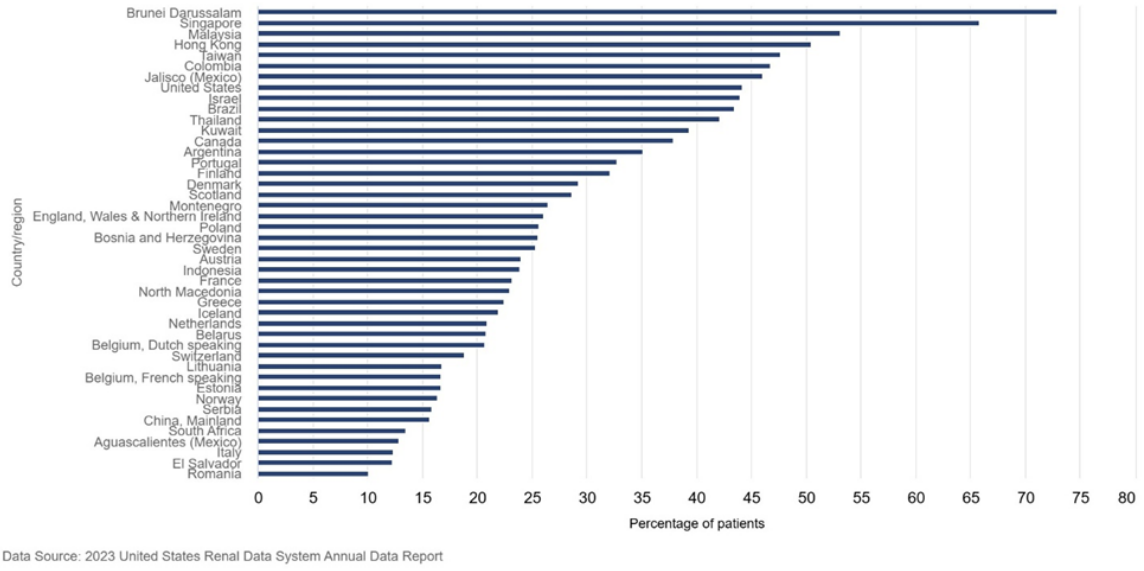


Figure 3: Percentage of incident cases of treated ESKD attributed to DKD in 2021 (adopted from USRDS – an international data system that collects, analyses, and distributes information about CKD and ESKD).

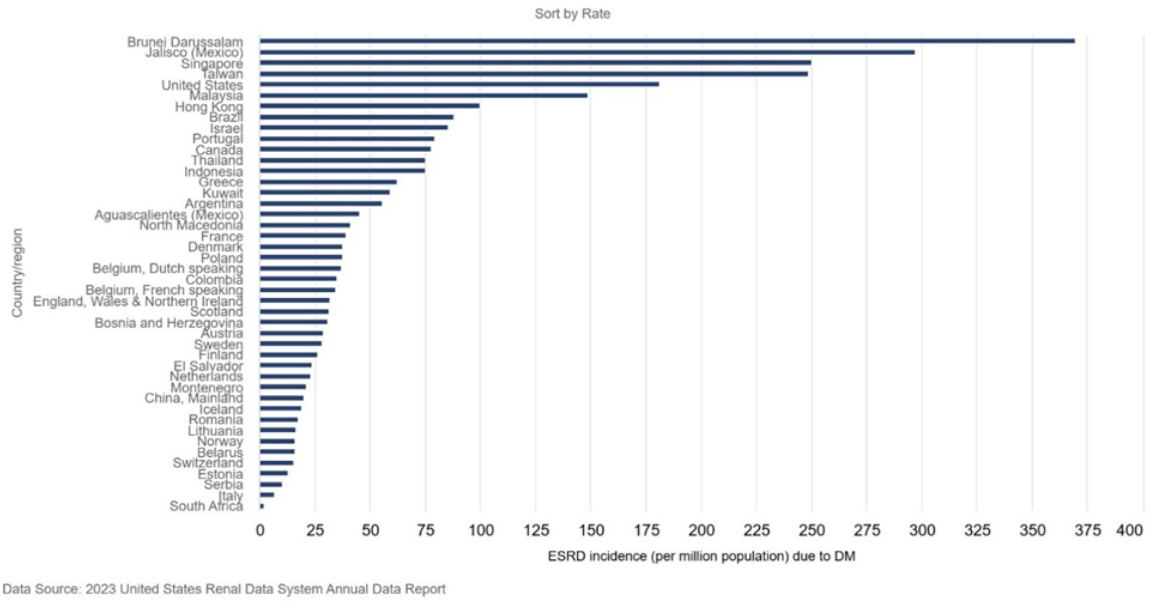


Figure 4: Incidence rates of treated ESKD attributed to DKD in 2021 (adopted from USRDS).

several genetic loci could be implicated in kidney function decline in a study involving 6,330 patients with diabetic kidney disease.[14] Some aberrant genes (SLC12A3 and PRKCE) can accelerate the development of DM-KF[15], with recent identifications of several unique genetic loci associated with diabetic nephropathy (DN) progression in a Singapore diabetic cohort study.[16] A Malaysian study identified CNDP1, NOS3 and MnSOD genes as risk factors, with significant differences between their ethnic subgroups.[17] FRMD3 gene polymorphism has also been implicated in DN patients with proteinuria in Thailand[18]; warranting further studies on the relationship of genetic variants and phenotypes, particularly those that are unique to the population subgroups in SEA countries. Currently, Brunei has started undergoing studies to map the genomic sequences of DM and CKD patients to improve understanding of the contribution of genetic factors in developing DKD and progression of kidney disease. These efforts aim to use platforms such as whole-exome sequencing and single nucleotide polymorphism genotyping to identify population-specific variants, which can eventually support personalised treatment approaches.

Several modifiable factors including obesity, HT, hyperlipidaemia and smoking have been found to adversely affect DM patients and increase predilection for CKD.[9] The STEPS study from 2016 showed that Brunei had the highest obesity rate in SEA with 63% of the population being overweight (Body Mass Index [BMI] $\geq$ 25 kg/m²) and 28% being regarded as obese (BMI 30 kg/m²).[21] The same study also showed a high adult smoking prevalence (19.9%) and hyperlipidaemia (51.3%) in the country.[21] Another local study reported that 35.8% of the adult population (40.4% men and 32.3% women) were found to have HT, with one quarter of the patients being previously undetected prior to the study.[22] The local HT prevalences in Brunei compared unfavourably with worldwide trends reported by the NCD-RisC study with 19.1 million individuals, where 24.1% and 20.1% of men and women were reported to have HT.[23]

Multi-racial studies have shown that first generation SEA immigrants have unique behavioural traits resulting in poorer health and DM literacy compared to their white counterparts.[19] Even after adjusting for age, gender, BMI, income and reported exercise levels, they were 30% more likely to have diagnosed DM, undiagnosed DM, develop macroalbuminuria and progress to ESKD.[20] The use of traditional and complementary alternative medicines is common in Brunei and can interfere with adherence to conventional treatments.[25] A recent study in Brunei found that 40.2% of ESKD patients used alternative medicine regardless of their socio-demographic background, reflecting a perceived gap in meeting healthcare needs through traditional medicine.[25] Even amongst the general population, Chong *et al*. found that 21% of 'healthy' hospital visitors have used complementary and alternative medicine within the past year of the study. [26] Another local study involving 118 patients with type 2 DM revealed that 63%

were non-adherent to their prescribed medications, with most showing poor knowledge about their treatment.[27] This may highlight a lack of personal responsibility for self-care and complacency associated with the fully-funded healthcare system. Additionally, health-seeking behaviours among the local population, especially older adults and those with limited education, are often influenced by fear and mistrust of Western-style hospital treatments, resulting in delayed diagnoses, poor medication compliance, and inadequate medical follow-up.[24] Socio-cultural beliefs and attitudes may also negatively impact chronic disease management, particularly in a healthcare environment focused more on acute, episodic illnesses than on long-term chronic care.[24]

The rate of economic development in Brunei, which occurs lock-step with urbanisation, has improved access to healthcare services and facilities. The establishment of satellite HD centers and proliferation of home-based therapies like PD and transplant have also widened treatment coverage for the population in the past decade. [3] The advent of the BDTR in 2012 means that all national data pertaining to dialysis and kidney disease prevalence and incidence were able to be reliably captured and utilised for international benchmarking.[28,29] While this accurate representation of the burden of ESKD and DKD provides valuable insights for developing targeted interventions, it also reveals challenging disease patterns that attract close scrutiny from the global community. **Figure 5** shows the overlapping influences of genetics, behavioural and environmental factors on DKD in Brunei.

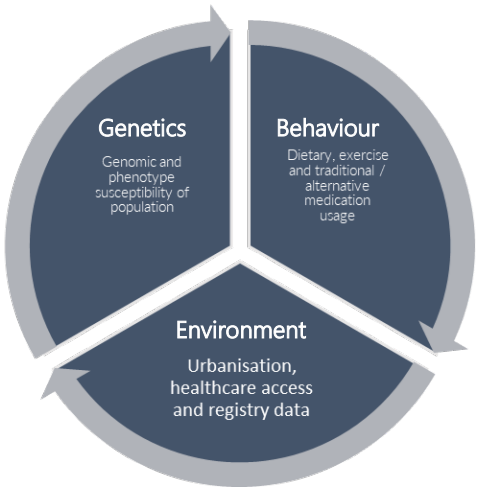


Figure 5: The epidemiological triad depicting factors that affect DKD.

Repercussion on healthcare costs

A joint economic evaluation by the Ministry of Health Brunei Darussalam and Thailand's Health Intervention and Technology Assessment Programme (HITAP) evaluated the financial, clinical, and operational impact of dialysis policy options. The study revealed that Brunei's current model—heavily reliant on in-center HD—is becoming financially and operationally unsustainable.[29] In 2023, the average annual cost per patient was BND 37,407 for HD, compared to BND 31,084 for Automated Peritoneal Dialysis (APD) and BND 33,190 for Continuous Ambulatory Peritoneal Dialysis (CAPD).[30] There was also no significant difference in health outcomes—measured in Quality-Adjusted Life Years (QALYs)—across all modalities. The study also concluded that an APD-first policy was found to be both more cost-effective and equally effective, with a negative incremental cost-effectiveness ratio (–837,200 BND per QALY), indicating strong dominance.[30] Furthermore, the societal burden is often underestimated with HD imposing the highest indirect costs at BND 5,304 per household annually, due to lost wages and caregiver responsibilities. CAPD averages BND 3,504, while APD, with its home-based and automated setup, has the lowest burden at just BND876—making it the most practical choice for working families.[30] Moreover, local studies have been done to show that short and long-term survival of patients on PD were superior to HD.[31,32]

With the current annual increase in ESKD patients, the total number of KRT patients in Brunei could exceed 1,800 by 2035, the year Brunei aims to achieve its national vision of self-sufficiency and economic sustainability (Wawasan 2035). Given the disproportionate growth between the national population and the ESKD population (**Figure 2**), it is estimated that by 2035, one in every 304 residents will have ESKD. **Figure 6** presents the projected renal dialysis expenditures from 2015 to 2035, based on a model developed by the Ministry of Health in 2015.[33] Notably, this model has proven accurate over the past decade, with dialysis costs rising to nearly 10% of the healthcare budget by 2025. If this trend continues, the renal dialysis budget could account for 25% of the healthcare budget by 2035, conflicting with the goals set by Wawasan 2035. Such a disproportionate increase in dialysis costs relative to the overall healthcare budget would negatively impact the delivery of healthcare services across all specialties. Without urgent policy shifts, dialysis costs could derail

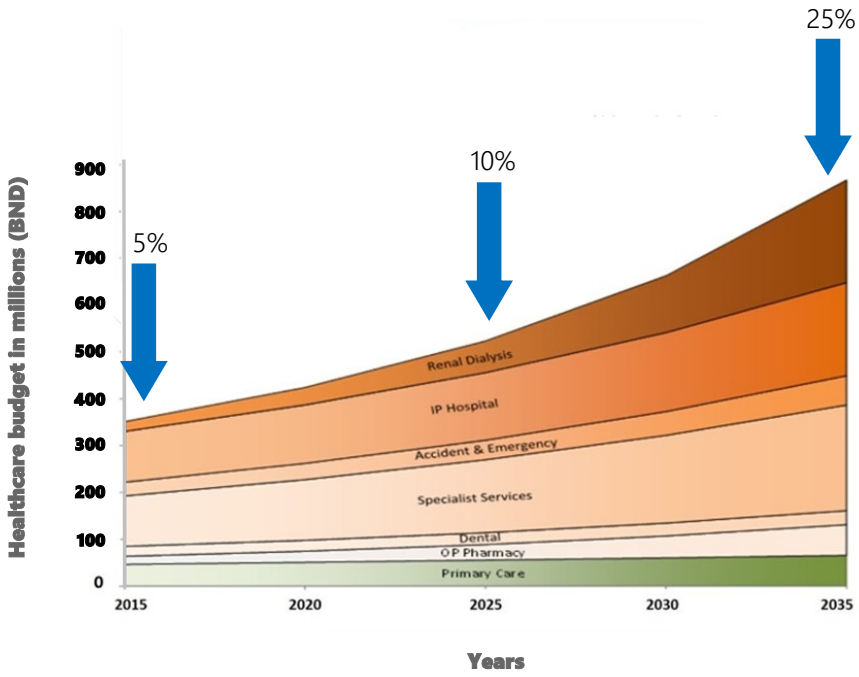


Figure 6: Impact of renal dialysis on healthcare budget in Brunei (2015-2035) (adopted by the Ministry of Health, with additional graphics modifications by the authors).

Brunei's future health system goals.

Recommendations

Greater fiscal investment in research is critical to developing country-specific solutions tailored to Brunei's unique public health challenges. Although the Brunei Research Council, under the Ministry of Finance and Economy (MOFE) and the 10th National Development Plan, was allocated a budget of BND 200 million, the priorities largely focus on energy, biodiversity, and data analytics.[34] In contrast, Singapore's Research, Innovation and Enterprise 2025 initiative has a budget of SGD 25 billion, with significant funding directed toward biosciences and medical technology research infrastructure.[35] This comparison highlights the need for Brunei to recognise the values of local research and realign research priorities to address pressing health concerns.

There is a pressing need for research focused on local genetic data gaps, the epidemiological impact of urbanisation, and the rise of NCDs. Establishing an NCD taskforce to coordinate multidisciplinary efforts across public health, endocrinology, general practice, geriatrics, cardiology and nephrology will facilitate community- and primary-care-level interventions aimed at reducing CKD and DM burden. Ultimately, increased funding and recognition for research must be prioritised. The healthcare emphasis should shift from reactive measures to proactive, preventive strategies grounded in robust scientific evidence and guided by relevant national needs.

Transformational reforms within Brunei's healthcare infrastructure and framework should be driven by resolute political resolve. Innovative changes are necessary to invigorate the system - transitioning from sole governmental reliance towards sustainable partnerships with non-governmental organisations (NGOs). Independent, renal-specific entities such as the National Kidney Foundation and other charitable organisations should be encouraged to proliferate with minimal bureaucratic hindrance. Additionally, mandatory insurance and pension schemes that cover healthcare costs, including dialysis and transplantation, should be introduced for all citizens and residents. Such reforms will help offset complacent attitudes in the population, fostering a culture of personal health accountability and encouraging alternative healthcare funding sources. Long-term healthcare sustainability depends on collective action to reduce government dependency and diversify healthcare funding between public and private sectors. Concerted collaborations between governmental bodies and NGOs are crucial to promote an ethos of

health accountability and literacy among the population.

CKD affects approximately 1 in 10 individuals[36], while DM impacts about 1 in 6 individuals worldwide.[37] The burden of disease is also higher in developing countries with higher proportion of undetected diseases.[37] Addressing CKD and DM at earlier stages is essential to prevent disease progression and associated complications which necessitates the active involvement and commitment of primary care professionals, who are often the first point of contact for patients, to initiate early disease-controlling interventions. To enable primary care providers to manage CKD stages 1 through 3 effectively, it is critical to empower them with standardised treatment guidelines and management algorithms developed in collaboration with tertiary care specialists. This approach facilitates timely diagnosis, appropriate therapeutic interventions, and regular monitoring, thereby reducing the likelihood of progression to advanced stages that require specialised tertiary care. Furthermore, the engagement of primary care and public health professionals is vital for the success of preventive strategies aimed at curbing the progression of DKD. Preventative programmes and education campaigns can significantly improve community understanding of CKD and DM, emphasising the severe long-term consequences that arise from late disease presentations. Such initiatives ultimately contribute to reducing disease burden, improving patient outcomes, and easing the strain on tertiary care in Brunei.

Given the proven local clinical and cost-savings benefits of PD and transplantation, health policies should proritised these modalities over HD for patients with ESKD. The local kidney transplant programme has made encouraging progress in the past decade and has achieved one of the highest rates of living-related transplantations in the region, but the country is still bereft of deceased programme.[38] Although a PD preference policy was introduced in 2013, the shift toward PD dominance among the ESKD population has been slow.[31] Implementing affirmative policies that mandate transplantation and PD over HD could transform the financial landscape of KRT, potentially saving the country millions of dollars annually.

Research direction

Policy decisions to alleviate DKD healthcare burden must come from local research activities to understand the disease pattern and formulate population-based strategies. Possible research direction can focus on the following areas:

1) Evaluation of alternate less-costly treatment for ESKD patients – potentially through propagation of modalities like kidney transplantation and PD, which can offer patients better quality of life.

2) Recent evidence has recommended usage of glucagon-like peptide analogues, sodium-glucose co-transporter-2 and mineralocorticoid receptor antagonists to delay progression of kidney disease and reduce cardiovascular mortality. Local studies can be done to explore the effects of these drugs in the local population.

3) Exploration of alternative means of health funding to counter the bourgeoning costs of local healthcare. Options like national health insurance, risk-pooling, and public-private partnerships can help reduce pressure on government spending. These funding models are used in many countries to make healthcare more sustainable while ensuring access for all.

4) Improving patients' accountability for their own health through health awareness and promotion events. More qualitative research into Bruneians' beliefs, practices, and knowledge around DM, kidney disease, and healthcare-seeking behaviour. Understanding local socio-cultural dynamics can guide culturally competent interventions.

5) Genetic mapping of healthy population or susceptible patients with kidney disease and /or DM to identify aberrant gene expressions that may predispose patients to severe diseases. A SEA collaborative research network on DKD, potentially including the establishment of a regional biobank, can be developed to better understand region-specific determinants.

6) Cost effectiveness of artificial intelligence and machine-learning methods to screen for CKD and DM in targeted high-risk population. Leverage the newly established Health Technology Assessment (HTA) unit to evaluate the cost-effectiveness and broader societal impact of preventive interventions targeting NCD, such as DM education, CKD screening and lifestyle modification programmes.

Conclusion

An alchemy of science, public andragogy and policy resolve; through collaborative multi-disciplinary

efforts, is needed to alleviate the economic and medical burden of DKD in the country. Maintaining current healthcare standards will require diversifying funding sources and developing a community-based framework that shifts away from dependence on the government and promotes personal responsibility for self-care.

Abbreviations

ESKD	End stage kidney disease
NCDs	Non-communicable diseases
DM	Diabetes mellitus
HT	Hypertension
CKD	Chronic kidney disease
HD	Haemodialysis
KRT	Kidney replacement therapy
PD	Peritoneal dialysis
USRDS	United States Renal Data System
DKD	Diabetic kidney disease
BDTR	Brunei diabetes and transplant registry
SEA	South East Asia
HITAP	Health Intervention and Technology Assessment Programme
BND	Brunei dollar
APD	Automated peritoneal dialysis
CAPD	Continuous peritoneal dialysis
QALYs	Quality-Adjusted Life Years
MOFE	Ministry of Finance and Economy
SGD	Singapore dollars
NGOs	Non-governmental organisations
HTA	Health Technology Assessment

Declarations

Conflict of interests

The authors declare no conflict of interests.

Ethical Statement

Ethic approval not required.

Acknowledgement

None.

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