Singapore Renal Registry
Annual Report 2023

National Registry of Diseases Office

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1. GLOSSARY

ASIR	Age-standardised incidence rate
ASPR	Age-standardised prevalence rate
Ca	Calcium
CKD5	Chronic kidney disease stage 5
CIR	Crude incidence rate
CPR	Crude prevalence rate
CVD	Cerebrovascular disease
DN	Diabetic nephropathy
eGFR	Estimated glomerular filtration rate
ESA	Erythropoietin stimulating agent
IHD	Ischemic heart disease
Kt/V	Fractional clearance of urea
GN	Glomerulonephritis
HD	Haemodialysis
hb	Haemoglobin
iPTH	Intact parathyroid hormone
PD	Peritoneal dialysis
pmp	Per million population
PO_4	Phosphate
PVD	Peripheral vascular disease
SRR	Singapore Renal Registry
URR	Urea reduction ratio
VWO	Voluntary Welfare Organisation

2. EXECUTIVE SUMMARY

The crude incidence rate (CIR) of chronic kidney disease stage 5 (CKD5) has increased from 408.9 per million population (pmp) in 2013 to 563.7 pmp in 2022. While the age-standardised incidence rate (ASIR) of CKD5 remained stable and ranged between 267.1 pmp and 300.3 pmp from 2013-2022, the ASIR of definitive dialysis increased from 171.2 pmp in 2013 to 194.0 pmp in 2023. The age-standardised prevalence rate (ASPR) of definitive dialysis also increased from 961.8 pmp in 2013 to 1,154.3 pmp in 2023. As of December 2023, there was a total of 9,196 Singapore residents on definitive dialysis, compared to 5,521 in 2013.

Males outnumbered females in both the incidence and prevalence rates of dialysis. In 2023, the ASIR for definitive dialysis was 239.7 pmp for males and 152.4 pmp for females, while the ASPR was 1,369.6 pmp for males and 957.7 pmp for females. The incidence and prevalence rates of dialysis were higher among Malays than Chinese and Indians. In 2023, the ASIR was 153.4 pmp for Chinese, 472.9 pmp for Malays and 212.2 pmp for Indians, while the ASPR was 896.8 pmp for Chinese, 2,995.6 pmp for Malays and 1,129.8 pmp for Indians. Haemodialysis (HD) was the predominant dialysis modality for dialysis patients, with 78.1% of the new patients and 86.9% of the prevalent patients on HD in 2023. The remaining incident and prevalent dialysis patients were on peritoneal dialysis (PD).

Diabetic nephropathy (DN) was the main cause of CKD5 among patients on dialysis. 63.0% of the new dialysis patients and 55.4% of the prevalent dialysis patients had DN in 2023. Cardiac events (32.9% of deaths) and infections (34.0% of deaths) were the two most common causes of death among prevalent patients on dialysis in 2023. After adjusting for demographics, CK5 etiology and co-morbidities, the risk of death was 1.5 times higher for patients on peritoneal dialysis (PD) compared to those on HD. However, the disparity in survival between HD and PD has narrowed over the years as the survival of HD patients remained stable while the survival of PD patients improved.

The management of prevalent patients on dialysis was assessed using several criteria: frequency of dialysis, management of urea, management of anaemia, and management of mineral and bone disease. 97.2% of the HD patients had thrice weekly dialysis in 2023. Urea was well managed in 97.5% of the HD patients and 39.8% of the PD patients, based on their urea reduction ratio or fractional clearance of urea in 2023. Anaemia was well managed in 73.5% of the HD patients and 62.5% of the PD patients, based on their haemoglobin level in 2023. Bone metabolism was well managed in 77.1%, 58.1% and 22.8% of the HD patients and 59.2%, 53.3% and 27.6% of the PD patients based on their calcium level, phosphate level and intact parathyroid hormone level respectively in 2023.

The ASIR of kidney transplant fluctuated over the years between 2013 and 2023 due to the small number of transplants done each year, ranging between 50 to 115 in the past decade. However, the ASPR of kidney transplant remained stable during the same period. The ASIR was 17.8 pmp, while the ASPR was 248.7 pmp in 2023.

Males outnumbered females in the incidence rates of kidney transplant up till 2022; and had consistently higher transplant prevalence rates than females throughout the years. In 2023, the ASIR of kidney transplant in females surpassed that for males for the first time in the period 2013-2023, at 17.3 pmp for males and 18.3 pmp for females. The ASPR was 268.0 pmp for males and 231.0 pmp for females. While there was no consistent ethnic difference in the incidence rate of transplant, the highest prevalence rate of transplant was observed among Chinese. In 2023, the ASIR was 18.7 pmp for Chinese, 10.2 pmp for Malays and 21.3 pmp for Indians, while the ASPR was 251.1 pmp for Chinese, 231.2 pmp for Malays and 225.4 pmp for Indians. Most transplants were performed locally. 88.9% of the transplants in 2023 were performed in Singapore. Glomerulonephritis (GN) was the main cause of CKD5 among patients with transplant. 46.5% of the new transplant patients and 64.1% of the prevalent transplant patients had GN in 2023.

Patients with kidney transplants from living donors had better survival (5-year graft survival 93.9%, 5-year patient survival 96.1%) than those with kidney transplants from deceased donors (5-year graft survival 86.2%, 5-year patient survival 91.2%). After adjusting for demographics, CKD5 etiology and co-morbidities, the risk of death was lower for CKD5 patients with transplant, regardless of donor type, than those who were on dialysis.

3. INTRODUCTION

Chronic kidney disease (CKD) is a worldwide epidemic[1], with diabetes as its leading cause. Based on the National Population Health Survey 2022, about 1 in 12 (8.5%) Singapore residents have diabetes[2]. Our ageing population further compounds the situation in Singapore as decline in kidney function tends to rise with age[3].

Estimated glomerular filtration rate (eGFR; glomerular filtration rate corrected to body surface area of $1.73m^2$) is one of the markers of kidney damage. Internationally, CKD is defined as eGFR <60 $mL/min/1.73m^2$. There are five stages of CKD. This report focuses on CKD5, the most severe stage of kidney failure, whereby the eGFR is <15 $ml/min/1.73m^2$ on at least two occasions >90 days apart. CKD5 patients may undergo dialysis, kidney transplant or conservative management after discussion with their doctor. This report focuses on CKD5 patients who were on renal replacement therapy (i.e. dialysis or kidney transplant). There are two main modalities of dialysis: haemodialysis (HD) and peritoneal dialysis (PD). Older patients and/or those with medical conditions are usually preferentially placed on PD, a gentler therapy compared to HD.

[1] Mallamaci F. Highlights of the 2015 ERA-EDTA congress: chronic kidney disease, hypertension. Nephrology Dialysis Transplant. 2016; 31(7): 1044-1046.
[2] National Population Health Survey 2022 (Household Interview and Health Examination). Ministry of Health, Singapore. https://www.moh.gov.sg/others/resources-and-statistics/nphs-2022 Accessed on 19 December 2023.
[3] Ayodele OE and Alebiosu CO. Burden of chronic kidney disease: an international perspective. Advanced Chronic Kidney Disease. 2010; 17(3): 215-224.

4. METHODOLOGY

The National Registry of Diseases Office (NRDO) collects and analyses epidemiological data to support policy planning and review as well as programme evaluation.

In most renal registries, only patients who initiated dialysis are captured[4]. There are also others, such as the United States Renal Data System[5], which capture only patients who survived >90 days after initiation of dialysis. However, these registries may underestimate the burden of kidney failure in the country and the workload of healthcare professionals. Hence, the Singapore Renal Registry (SRR) captures patients with CKD5, regardless whether they have initiated dialysis or survived >90 days after initiation of dialysis.

In 2007, the Singapore General Hospital started providing their list of patients with eGFR <15 ml/min/1.73m^2 to the SRR. This practice was followed by the National University Hospital in 2009 and the remaining public and private healthcare institutions in 2010, after legislation mandating notification of CKD5 from all healthcare institutions was put in place by the Ministry of Health.

<u>Data sources</u>

The SRR receives CKD5 case notifications from the public hospitals, dialysis centres, private nephrology clinics, kidney transplant centres and the National Organ Transplant Unit.

From 1999 to 2009, case finding for CKD5 was guided by serum creatinine ≥10 mg/dl or ≥880 μmol/L, or initiation of renal replacement therapy. Since 2010, to ensure that case coverage is as comprehensive as possible, the guiding principle was subsequently changed to serum creatinine ⩾500 μmol/L, eGFR <15 ml/min/1.73m^2, or initiation of renal replacement therapy. Once a potential CKD5 case is identified, the SRR monitors the patient's eGFR readings that are at least six months apart before accepting the case as CKD5. The monitoring period is to let the eGFR readings stabilise over a period of time for accurate case ascertainment and to rule out the possibility of acute kidney impairment. This is in accordance with the Kidney Disease Outcomes Quality Initiative guidelines[6].

The registry coordinators confirm the diagnosis of CKD5 by viewing the patients' medical records, before extracting relevant detailed clinical information from there.

For this report, the death status of all patients registered in the SRR were updated till 30 April 2024 by matching the patients' unique National Registration Identity Card number with information from the Death Registry.

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[4] Liu FX, Rutherford P, Smoyer-Tomic K, Prichard S, Laplante S. A global overview of renal registries: a systematic review. BMC Nephrology. 2015; 16: 31.
[5] United States Renal Data System (USRDS). www.usrds.org Accessed on 1 Mar 2021.
[6] Chronic Kidney Disease: Evaluation, Classification, and Stratification 2002. National Kidney Foundation, New York.

The Singapore population estimates used to calculate the incidence rates and prevalence rates in this report were obtained from the Singapore Department of Statistics, which releases mid-year population estimates of Singapore residents (i.e. Singapore citizens and permanent residents) annually[7]. The Segi World population estimates used for age standardisation are available on the World Health Organisation website[8].

This report focuses on Singapore residents with CKD5 and underwent dialysis or kidney transplant in 2013 to 2023, as they stood on 6 June 2024. Statistics on prevalence and survival included patients since the start of the SRR in 1999. A detailed definition of each indicator is given at the start of each section of this report.

[7] SingStat Table Builder, Population and Population Structure, Annual Population, Singapore Residents by age group, ethnic group and sex. Department of Statistics, Singapore. www.tablebuilder.singstat.gov.sg Accessed on 1 October 2024.
[8] Omar BA et al. Age standardization of rates: a new WHO standard. GPE discussion paper series: no. 31. EIP.GPE/EBD World Health Organization 2001.

5. FINDINGS

5.1 Overview of dialysis and transplant

Table 5.1.1 shows the stock and flow of patients in the past five years from 2019 to 2023. The number of new dialysis patients, deaths among dialysis patients, and prevalent dialysis patients generally increased over the years. The number of new kidney transplant patients dropped between 2019-2020, but rose slightly thereafter. The numbers of prevalent kidney transplant patients remained stable over the years.

Table 5.1.1: Stock and flow in 2019 – 2023

	2019	2020	2021	2022	2023
Incidence					
Definitive dialysis	1208	1336	1413	1421	1518
Transplant	105	50	74	76	99
Death					
Definitive dialysis	908	957	1030	1293	1254
Transplant	33	30	34	41	37
Prevalence					
Definitive dialysis	7766	8222	8675	8885	9196
Transplant	1622	1612	1613	1612	1641

All dialysis and transplant patients are tracked by the SRR at the end of every year as part of the year-end follow-up monitoring. Patients can be followed up for dialysis or consultation with a nephrologist, and the prevalence numbers in Table 5.1.2 were based on the last follow-up visit for each patient.

Not only are HD patients followed up by their nephrologists in the public hospital[9], they also have routine follow-up at the dialysis centre where they go for their regular dialysis. In 2023, two-thirds of the prevalent HD patients were last followed up at dialysis centres run by the Voluntary Welfare Organisations (VWOs 65.8%), while the remaining were followed by the private clinics and dialysis centres (32.5%), and public hospitals and affiliated dialysis centres (1.6%).

On the other hand, as PD is done at home, follow-up among PD patients is typically for consultation with their nephrologists, where PD was initiated. Almost all the prevalent PD patients (98.6%) were last followed up at the public hospitals and affiliated dialysis centres in 2023.

Similarly, follow-up among transplant patients is typically for consultation with their nephrologists, where transplant was done. 9 in 10 prevalent transplant patients (90.9%) were followed up at the public hospitals and affiliated dialysis centres in 2023.

A detailed breakdown of the prevalent patients by service providers is shown in the Annex.

[9] Patients on HD routinely follow up with a primary nephrologist at the Specialist Outpatient Clinics (SOC) in the RH once every 4-6 months.

Table 5.1.2: Prevalent patients as at 31 December 2023

	HD		PD		Transplant	
	Number	%	Number	%	Number	%
Public hospitals and affiliated dialysis centres	128	1.6	1191	98.6	1490	90.8
Dialysis centres under Voluntary Welfare Organisations	5260	65.8	0	0.0	0	0.0
Private clinics and dialysis centres	2600	32.5	17	1.4	150	9.1
Overseas	0	0.0	0	0.0	1	0.1
Total	7988	100	1208	100	1641	100

5.2 Incidence of CKD5

The incidence rate of CKD5 in each year was calculated by taking the number of new CKD5 patients in a year, divided by the number of Singapore residents in the same year. The count was based on the diagnosis date of CKD5. Patients were categorised into 10-year age groups and age standardisation was done using the direct method with the Segi World population as the reference population.

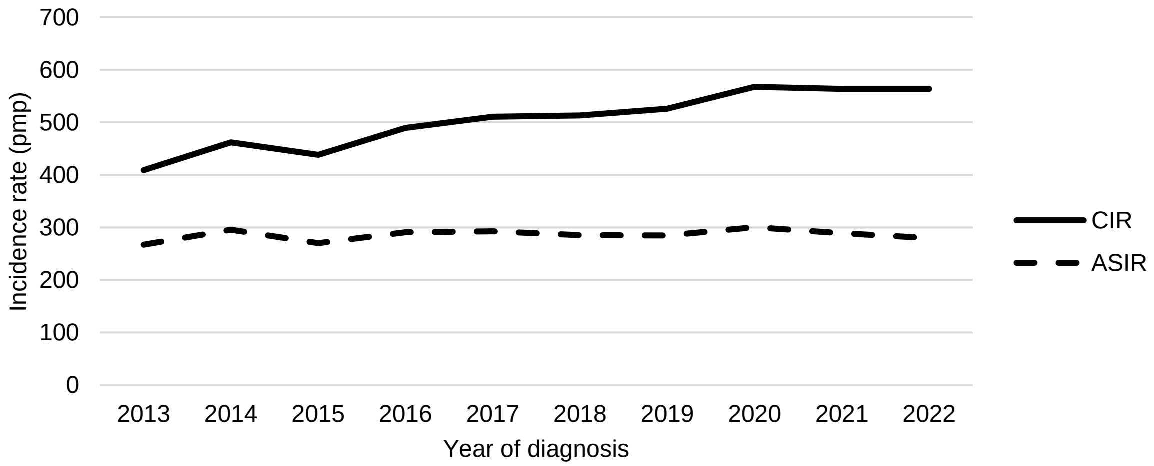
As the registry monitors the patient's eGFR readings for at least six months before accepting a case as CKD5 to allow for accurate case ascertainment, all statistics related to new CKD5 patients for 2023 are not shown in this section.

The number of new patients diagnosed with CKD5 increased from 1,572 in 2013 to 2,296 in 2022, an increase of 46% (Table 5.2.1, Figure 5.2.1). Correspondingly, the CIR increased significantly from 408.9 pmp in 2013 to 563.7 pmp in 2022 ($p<0.001$). However, the ASIR remained stable, ranging between 267.1 pmp and 300.3 pmp during the same period ($p=0.335$). The stable ASIR trend in relation to the significant rise in CIR suggests that the rise in CIR was driven mainly by Singapore's ageing population.

Table 5.2.1: Incidence number and rate (pmp) of CKD5

Year of diagnosis	Number	CIR	ASIR
2013	1572	408.9	267.1
2014	1788	461.9	295.6
2015	1711	438.4	270.3
2016	1925	489.4	291.0
2017	2025	510.6	292.8
2018	2050	513.2	285.0
2019	2117	525.8	284.7
2020	2295	567.5	300.3
2021	2246	563.4	289.1
2022	2296	563.7	279.9
P for trend	-	<0.001**	0.335

Figure 5.2.1: Incidence rate (pmp) of CKD5



Significant increases in CKD incidence were observed for those aged 30-39 years (p=0.028), 70-79 years (p=0.041), and 80 years and above (p=0.037). However, among those aged 50-59 years, age-specific CKD5 incidence dropped instead (p=0.029) (Table 5.2.2).

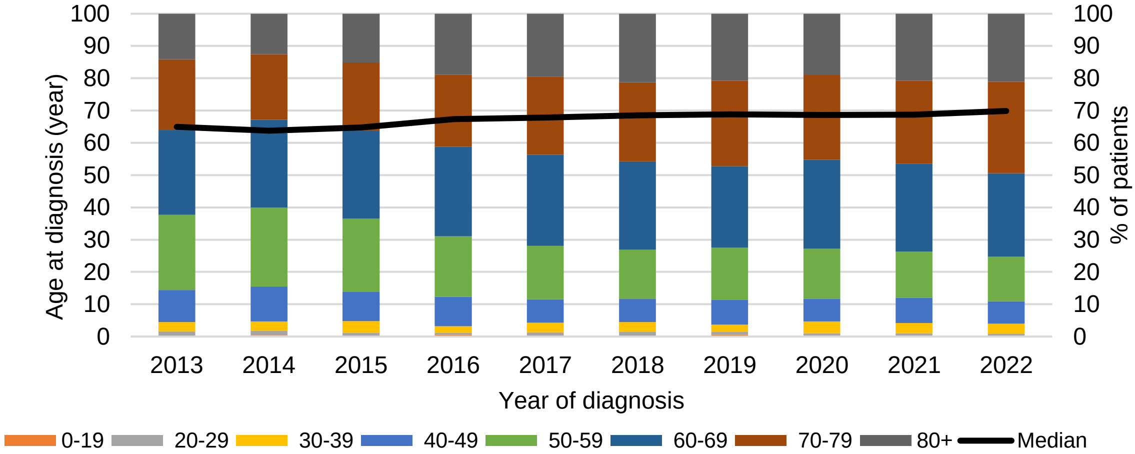
Table 5.2.2: Age distribution (%) and age-specific incidence rate (pmp) of CKD5

Year of diagnosis	Age 0-19			Age 20-29			Age 30-39			Age 40-49		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2013	5	0.3	5.7	21	1.3	40.2	45	2.9	74.7	155	9.9	246.5
2014	8	0.4	9.4	24	1.3	45.3	51	2.9	85.8	194	10.9	310.6
2015	5	0.3	5.9	14	0.8	26.2	62	3.6	104.8	156	9.1	251.5
2016	10	0.5	12.0	12	0.6	22.2	40	2.1	68.1	176	9.1	286.4
2017	4	0.2	4.8	22	1.1	40.1	61	3.0	105.1	147	7.3	239.0
2018	7	0.3	8.6	21	1.0	38.4	64	3.1	109.4	146	7.1	238.8
2019	11	0.5	13.5	18	0.9	33.5	50	2.4	84.1	163	7.7	266.1
2020	5	0.2	6.2	18	0.8	33.9	85	3.7	142.3	162	7.1	265.1
2021	4	0.2	5.1	19	0.8	36.8	72	3.2	122.0	174	7.7	293.5
2022	1	0.0	1.3	20	0.9	39.0	71	3.1	116.8	159	6.9	263.2
P for trend	-	-	0.183	-	-	0.861	-	-	0.028*	-	-	0.894

Year of diagnosis	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2013	367	23.3	617.9	413	26.3	1122.0	344	21.9	1953.4	222	14.1	2704.0
2014	437	24.4	723.6	487	27.2	1240.1	363	20.3	1982.4	224	12.5	2566.0
2015	388	22.7	635.9	464	27.1	1097.1	363	21.2	1974.5	259	15.1	2771.6
2016	359	18.6	583.6	536	27.8	1191.4	428	22.2	2232.1	364	18.9	3721.9
2017	335	16.5	545.2	571	28.2	1223.7	488	24.1	2307.9	397	19.6	3920.0
2018	314	15.3	511.9	560	27.3	1157.5	502	24.5	2193.4	436	21.3	4079.3
2019	343	16.2	563.7	533	25.2	1065.7	559	26.4	2284.2	440	20.8	3804.4
2020	355	15.5	589.8	631	27.5	1227.6	604	26.3	2314.2	435	19.0	3508.8
2021	322	14.3	551.2	612	27.2	1181.5	576	25.6	2115.3	467	20.8	3556.4
2022	317	13.8	534.7	594	25.9	1108.3	650	28.3	2208.1	484	21.1	3563.4
P for trend	-	-	0.029*	-	-	0.791	-	-	0.041*	-	-	0.037*

The median age at diagnosis of CKD5 increased from 64.9 years in 2013 to 69.9 years in 2022 (p<0.001); the percentage of CKD5 patients aged 60 years and above also increased from 62.3% in 2013 to 75.3% in 2022 (Figure 5.2.2a).

Figure 5.2.2a: Median age (years) and age distribution (%) of CKD5 patients



The age-specific incidence rate of CKD5 increased with age, with those aged 80 years and above having the highest incidence rate (Figure 5.2.2b, Figure 5.2.3).

Figure 5.2.2b: Age-specific incidence rate (pmp) of CKD5 across years

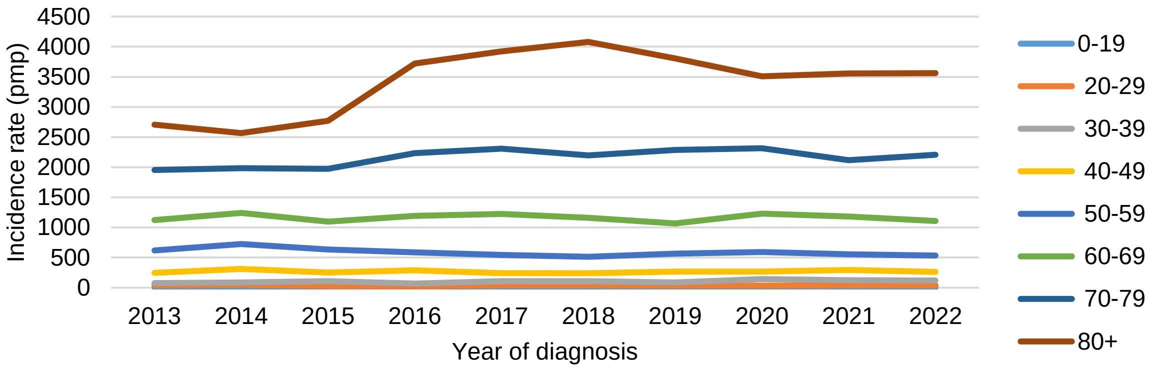
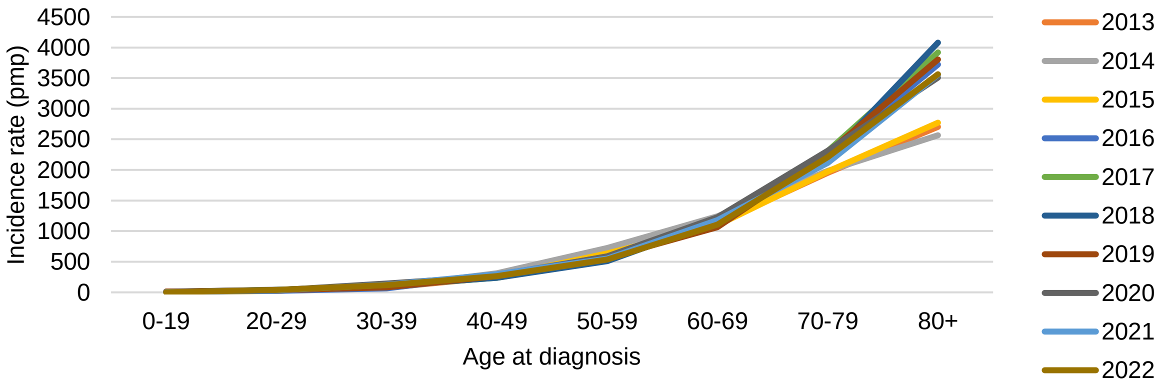


Figure 5.2.3: Age-specific incidence rate (pmp) of CKD5 across age groups



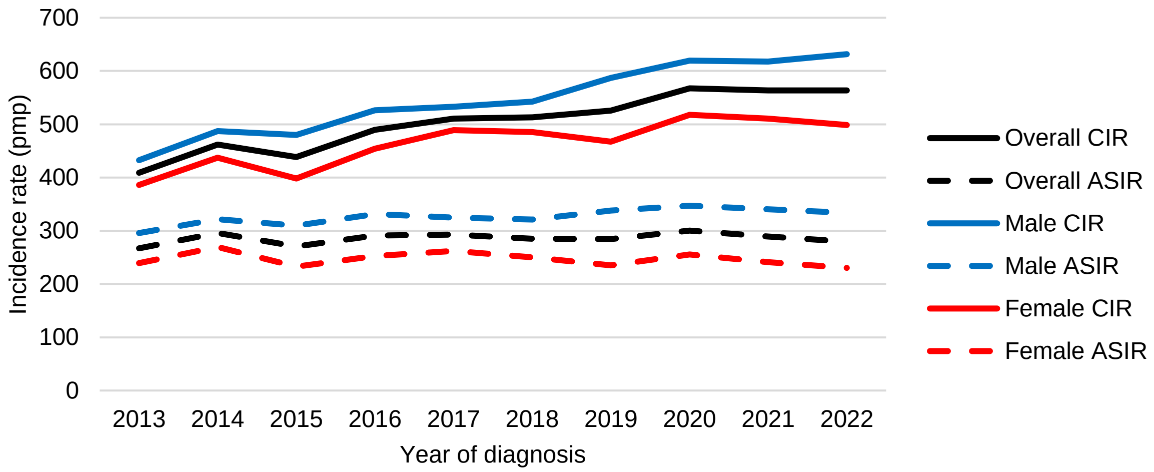
Across the past decade, males consistently accounted for a slightly higher percentage of individuals suffering from CKD5 compared to females. The ASIRs of CKD5 were consistently higher among males than females across the years (Table 5.2.3, Figure 5.2.4). In 2022, the ASIR was 334.0 pmp and 230.3 pmp for males and females respectively. While there was a significant increase in the ASIR of CKD5 among males (p=0.005), that of females remained relatively unchanged (p=0.373). This could be due to the higher prevalence of risk factors of CKD5 such as diabetes and hypertension in males compared to females, as consistently observed in the National Population Health Survey series, including the latest survey cycle with health examination in 2022[10].

Table 5.2.3: Incidence number and rate (pmp) of CKD5 by sex

Male				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2013	818	52.0	432.5	295.8
2014	927	51.8	487.3	321.9
2015	920	53.8	480.0	309.8
2016	1015	52.7	526.0	331.5
2017	1036	51.2	533.0	324.5
2018	1061	51.8	542.5	321.3
2019	1156	54.6	587.0	338.2
2020	1225	53.4	619.5	347.1
2021	1207	53.7	618.0	340.2
2022	1257	54.7	631.6	334.0
P for trend	-	-	<0.001**	0.005*
Female				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2013	754	48.0	386.1	239.5
2014	861	48.2	437.4	269.5
2015	791	46.2	398.3	232.4
2016	910	47.3	454.1	252.8
2017	989	48.8	489.1	261.9
2018	989	48.2	485.2	249.9
2019	961	45.4	467.2	235.1
2020	1070	46.6	517.7	255.8
2021	1039	46.3	510.9	241.1
2022	1039	45.3	498.8	230.3
P for trend	-	-	0.001**	0.373

[10] National Population Health Survey 2022 (Household Interview and Health Examination). Ministry of Health, Singapore. https://www.moh.gov.sg/others/resources-and-statistics/nphs-2022 Accessed on 19 December 2023.

Figure 5.2.4: Incidence rate (pmp) of CKD5 by sex



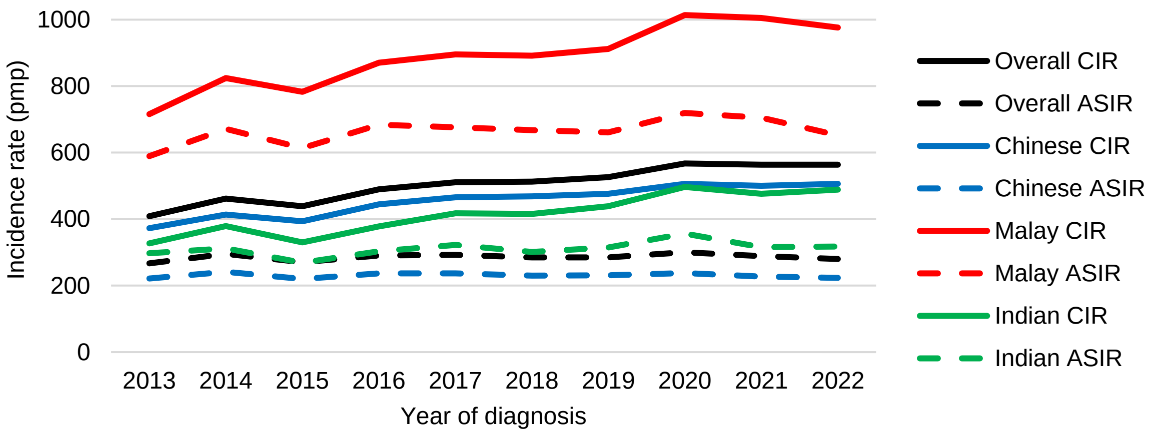
Over the past decade, the ASIRs of CKD5 were consistently higher among Malays than Chinese and Indians (Table 5.2.4, Figure 5.2.5). In 2022, the ASIR among Malays was 652.5 pmp, which was about threefold higher compared to Chinese (223.2 pmp) and twofold higher compared to Indians (317.5 pmp). While significant rises were observed in the CIR of CKD5 among all three ethnicities, no significant changes in ASIR were observed for all three groups, suggesting that the increase in CKD5 incidence was mainly driven by population ageing.

Table 5.2.4: Incidence number and rate (pmp) of CKD5 by ethnicity

Chinese				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2013	1064	67.7	372.8	221.8
2014	1189	66.5	413.7	241.5
2015	1142	66.7	393.8	220.1
2016	1299	67.5	444.4	236.7
2017	1373	67.8	465.7	236.9
2018	1390	67.8	468.1	229.7
2019	1427	67.4	476.7	230.7
2020	1521	66.3	505.9	237.8
2021	1482	66.0	500.7	227.7
2022	1528	66.6	506.1	223.2
P for trend	-	-	<0.001**	0.905
Malay				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2013	367	23.3	715.8	589.5
2014	426	23.8	824.5	671.7
2015	408	23.8	783.2	613.4
2016	458	23.8	870.9	683.6
2017	475	23.5	895.0	675.9
2018	478	23.3	892.1	667.1
2019	493	23.3	911.6	661.0
2020	553	24.1	1013.8	719.4
2021	547	24.4	1004.7	705.3

2022	541	23.6	976.3	652.5
P for trend	-	-	<0.001**	0.069
Indian				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2013	115	7.3	327.2	296.9
2014	134	7.5	379.6	311.9
2015	117	6.8	329.6	268.9
2016	135	7.0	378.3	303.6
2017	150	7.4	418.0	322.9
2018	150	7.3	416.1	301.1
2019	159	7.5	438.5	314.6
2020	180	7.8	496.9	356.5
2021	169	7.5	476.2	316.0
2022	179	7.8	488.5	317.5
P for trend	-	-	<0.001**	0.099

Figure 5.2.5: Incidence rate (pmp) of CKD5 by ethnicity



5.3 Incidence of ever-started dialysis

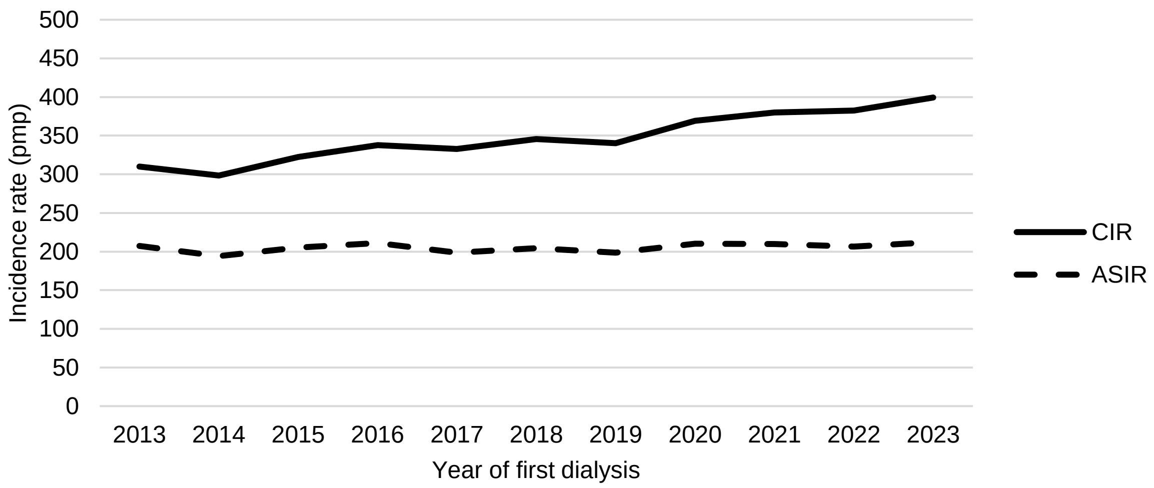
The incidence rate of ever-started dialysis[11] in each year was calculated by taking the number of new patients who ever-started dialysis in a year, divided by the number of Singapore residents in the same year. The modality was based on the first dialysis. Patients were categorised into 10-year age groups and age standardisation was done using the direct method with the Segi World population as the reference population.

The number of new patients who initiated dialysis increased from 1,191 in 2013 to 1,657 in 2023, an approximately 40% increase in 10 years (Table 5.3.1, Figure 5.3.1). Correspondingly, the CIR increased significantly from 309.8 pmp in 2013 to 399.3 pmp in 2023 (p<0.001). However, the ASIR remained stable and ranged between 194.1 pmp and 212.2 pmp during the same period (p=0.172).

Table 5.3.1: Incidence number and rate (pmp) of ever-started dialysis

Year of first dialysis	Number	CIR	ASIR
2013	1191	309.8	207.4
2014	1155	298.4	194.1
2015	1258	322.3	205.2
2016	1328	337.6	210.9
2017	1319	332.6	198.7
2018	1381	345.7	204.5
2019	1370	340.3	198.6
2020	1494	369.4	210.1
2021	1515	380.0	209.9
2022	1558	382.5	206.6
2023	1657	399.3	212.2
P for trend	-	<0.001**	0.172

Figure 5.3.1: Incidence rate (pmp) of ever-started dialysis



[11] Refers to CKD5 patients who had ever initiated dialysis, including those who did not survive beyond 90 days after first dialysis

The age-specific incidence rate of ever-started dialysis increased significantly for those aged 30-39 years ($p=0.003$) and 70-79 years ($p=0.001$), but it dropped for those aged 50-59 years ($p=0.027$), and 80 years and above ($p=0.046$) (Table 5.3.2).

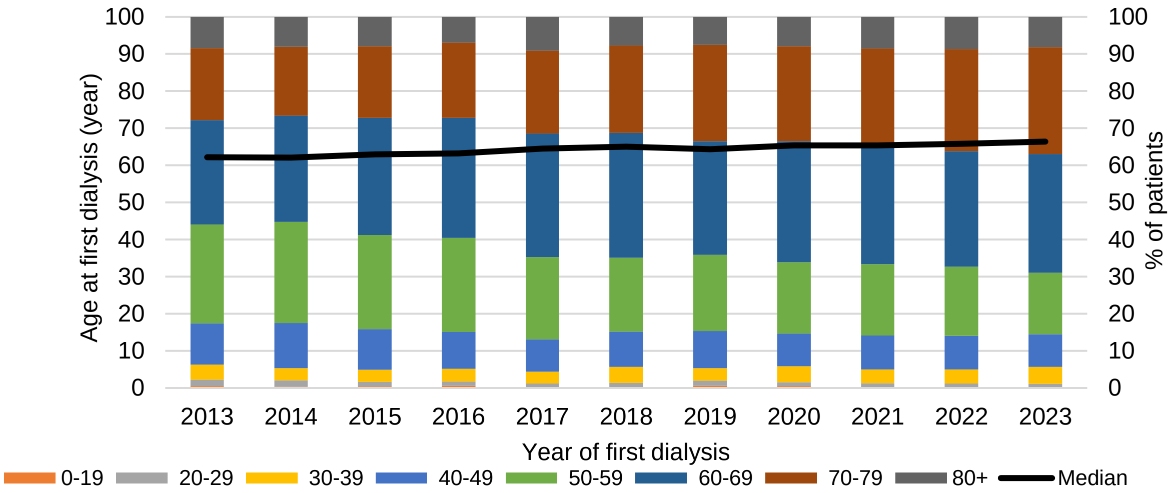
Table 5.3.2: Age distribution (%) and age-specific incidence rate (pmp) of ever-started dialysis

Year of first dialysis	Age 0-19			Age 20-29			Age 30-39			Age 40-49		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2013	6	0.5	6.9	21	1.8	40.2	48	4.0	79.7	132	11.1	209.9
2014	4	0.3	4.7	20	1.7	37.8	38	3.3	63.9	140	12.1	224.2
2015	5	0.4	5.9	16	1.3	29.9	41	3.3	69.3	138	11.0	222.5
2016	8	0.6	9.6	15	1.1	27.7	46	3.5	78.3	131	9.9	213.1
2017	3	0.2	3.6	13	1.0	23.7	42	3.2	72.4	115	8.7	187.0
2018	4	0.3	4.9	15	1.1	27.4	60	4.3	102.5	131	9.5	214.2
2019	8	0.6	9.8	19	1.4	35.4	46	3.4	77.4	137	10.0	223.7
2020	8	0.5	10.0	15	1.0	28.2	65	4.4	108.8	131	8.8	214.4
2021	4	0.3	5.1	15	1.0	29.1	57	3.8	96.6	138	9.1	232.8
2022	0	0.0	0.0	19	1.2	37.0	59	3.8	97.0	141	9.1	233.4
2023	3	0.2	3.8	16	1.0	31.6	75	4.5	120.3	146	8.8	238.3
P for trend	-	-	0.738	-	-	0.614	-	-	0.003**	-	-	0.112

Year of first dialysis	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2013	318	26.7	535.4	335	28.1	910.1	231	19.4	1311.8	100	8.4	1218.0
2014	315	27.3	521.6	331	28.7	842.9	214	18.5	1168.7	93	8.1	1065.4
2015	319	25.4	522.8	397	31.6	938.7	243	19.3	1321.8	99	7.9	1059.4
2016	337	25.4	547.8	430	32.4	955.8	269	20.3	1402.9	92	6.9	940.7
2017	292	22.1	475.2	439	33.3	940.8	295	22.4	1395.1	120	9.1	1184.9
2018	275	19.9	448.4	464	33.6	959.1	325	23.5	1420.0	107	7.7	1001.1
2019	281	20.5	461.8	420	30.7	839.8	356	26.0	1454.7	103	7.5	890.6
2020	288	19.3	478.5	486	32.5	945.5	383	25.6	1467.4	118	7.9	951.8
2021	292	19.3	499.8	477	31.5	920.8	404	26.7	1483.6	128	8.4	974.8
2022	290	18.6	489.2	486	31.2	906.8	428	27.5	1453.9	135	8.7	993.9
2023	275	16.6	456.0	529	31.9	956.9	478	28.8	1498.9	135	8.1	964.9
P for trend	-	-	0.027*	-	-	0.513	-	-	0.001**	-	-	0.046*

The median age at first dialysis increased from 62.1 years in 2013 to 66.4 years in 2023 ($p<0.001$), while the percentage of ever-started dialysis patients aged 60 years and above increased from 55.9% to 68.8% (Figure 5.3.2a).

Figure 5.3.2a: Median age (years) and age distribution (%) of ever-started dialysis patients



The age-specific incidence rates of ever-started dialysis increased with age, and it was highest for those aged 70 to 79 years (Figure 5.3.2b, Figure 5.3.3). A decline over time was observed among those aged 50-59 years ($p=0.027$) and 80 years or older ($p=0.046$), particularly the latter. While age in itself is not a contraindication for dialysis, it may not be the best treatment option for elderly CKD5 patients due to multiple age-related comorbidities, geriatric syndromes, and functional impairment[12]. In such elderly patients, conservative treatment (management of CKD5 without dialysis or transplant by preserving residual kidney function and reducing symptoms) may be a viable option instead, as dialysis may not confer benefits or survival advantage in the presence of multiple comorbidities[13].

[12] Ahmed, F.A and Catic, A. G. Decision-Making in Geriatric Patients with End-Stage Renal Disease: Thinking Beyond Nephrology. J Clin Med. 2018; 8(1)

[13] The little known alternative to dialysis. Temasek. https://www.temasek.com.sg/en/news-and-resources/stories/community/the-little-known-alternative-to-dialysis. Accessed 4 Nov 2024.

Figure 5.3.2b: Age-specific incidence rate (pmp) of ever-started dialysis across years

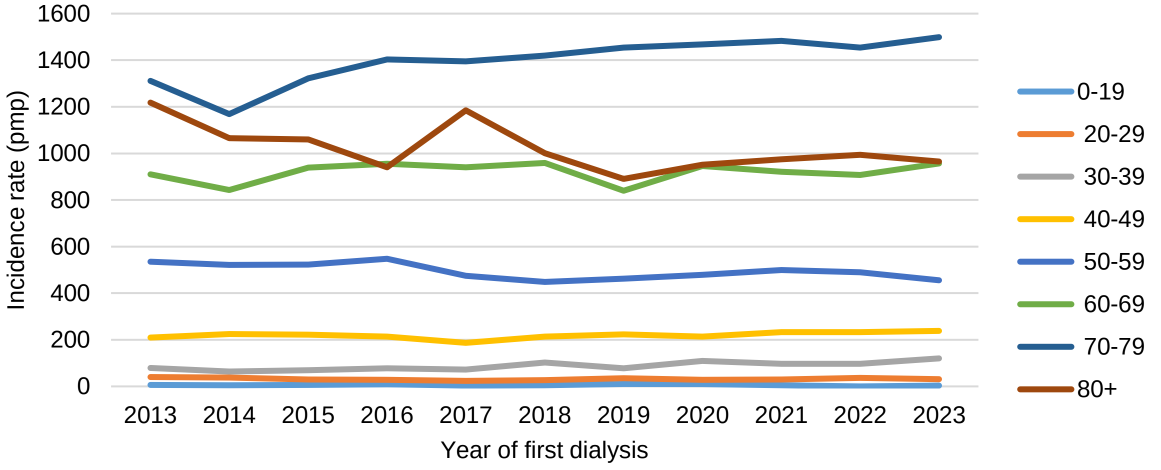
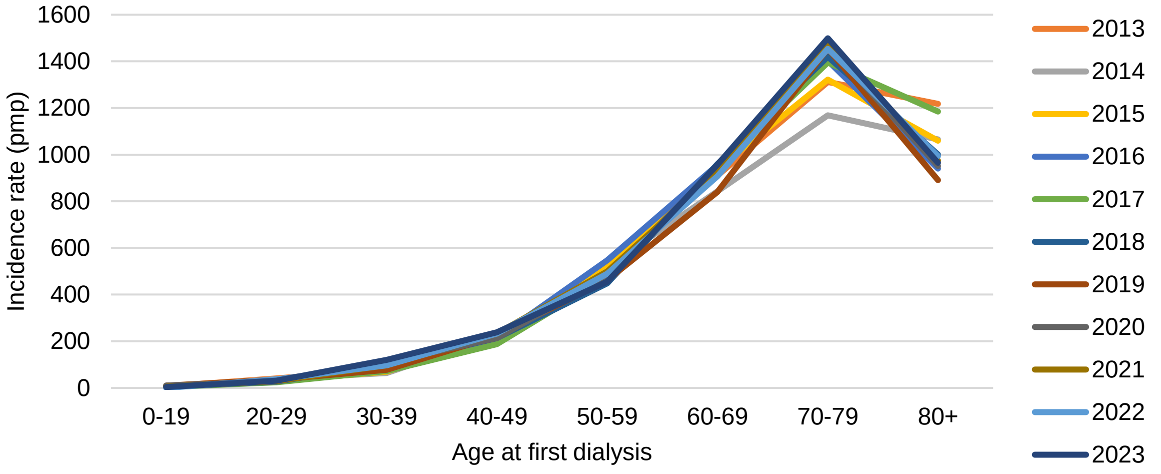


Figure 5.3.3: Age-specific incidence rate (pmp) of ever-started dialysis across age groups



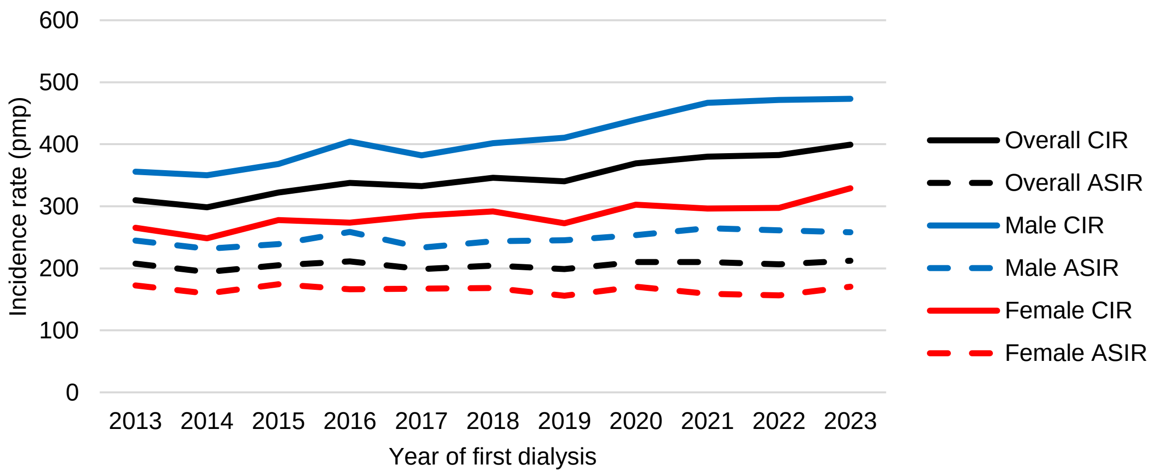
The ASIRs of ever-started dialysis were consistently higher among males than females across the years (Table 5.3.3, Figure 5.3.4). In 2023, the ASIR was 258.4 pmp and 170.2 pmp for males and females respectively. Similar to the sex trends of CKD5 incidence (Table 5.2.3), the ASIR of dialysis initiation among males increased significantly (p=0.016), while no significant changes were observed in that of females (p=0.312).

Table 5.3.3: Incidence number and rate (pmp) of ever-started dialysis by sex

Male				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	673	56.5	355.8	244.6
2014	666	57.7	350.1	231.6
2015	706	56.1	368.4	239.1
2016	780	58.7	404.2	258.7
2017	743	56.3	382.3	233.5

2018	786	56.9	401.9	243.6
2019	809	59.1	410.8	245.3
2020	869	58.2	439.4	253.7
2021	912	60.2	466.9	264.7
2022	938	60.2	471.3	261.3
2023	957	57.8	473.3	258.4
P for trend	-	-	<0.001**	0.016*
Female				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	518	43.5	265.2	172.5
2014	489	42.3	248.4	159.6
2015	552	43.9	277.9	174.3
2016	548	41.3	273.4	166.2
2017	576	43.7	284.8	167.5
2018	595	43.1	291.9	168.3
2019	561	40.9	272.8	155.8
2020	625	41.8	302.4	170.2
2021	603	39.8	296.5	159.0
2022	620	39.8	297.6	156.4
2023	700	42.2	329.0	170.2
P for trend	-	-	0.001**	0.312

Figure 5.3.4: Incidence rate (pmp) of ever-started dialysis by sex

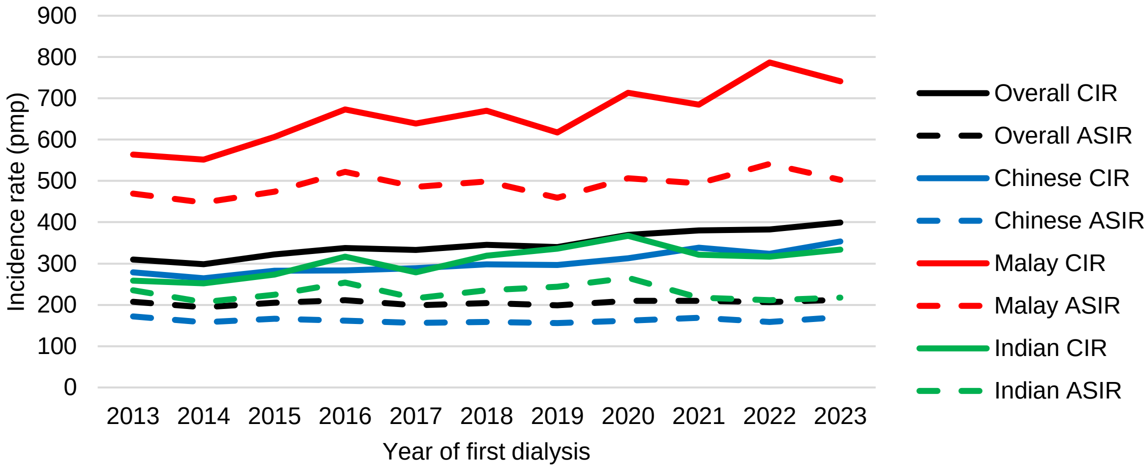


The ASIRs of ever-started dialysis were consistently higher among Malays than Chinese and Indians across the years (Table 5.3.4, Figure 5.3.5). In 2023, the ASIR was 170.6 pmp, 502.9 pmp and 217.4 pmp for Chinese, Malays and Indians respectively. No ethnic group exhibited a significant increase in the ASIR of ever-started dialysis.

Table 5.3.4: Incidence number and rate (pmp) of ever-started dialysis by ethnicity

Chinese				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	795	66.8	278.6	172.0
2014	760	65.8	264.4	157.6
2015	819	65.1	282.4	166.1
2016	829	62.4	283.6	161.8
2017	851	64.5	288.6	156.0
2018	885	64.1	298.1	158.9
2019	887	64.7	296.3	155.9
2020	940	62.9	312.6	161.7
2021	1002	66.1	338.5	168.9
2022	976	62.6	323.3	158.5
2023	1086	65.5	353.5	170.6
P for trend	-	-	<0.001**	0.941
Malay				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	289	24.3	563.7	469.1
2014	285	24.7	551.6	447.7
2015	316	25.1	606.6	473.9
2016	354	26.7	673.1	522.0
2017	339	25.7	638.8	485.4
2018	359	26.0	670.0	498.8
2019	334	24.4	617.6	459.0
2020	389	26.0	713.1	506.3
2021	373	24.6	685.1	493.8
2022	436	28.0	786.8	541.2
2023	416	25.1	741.1	502.9
P for trend	-	-	<0.001**	0.052
Indian				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	91	7.6	258.9	235.0
2014	89	7.7	252.1	206.6
2015	97	7.7	273.3	224.1
2016	113	8.5	316.6	254.1
2017	100	7.6	278.7	216.0
2018	115	8.3	319.0	235.7
2019	122	8.9	336.4	244.2
2020	133	8.9	367.1	265.4
2021	114	7.5	321.2	217.3
2022	116	7.4	316.6	211.0
2023	125	7.5	333.5	217.4
P for trend	-	-	0.004**	0.837

Figure 5.3.5: Incidence rate (pmp) of ever-started dialysis by ethnicity



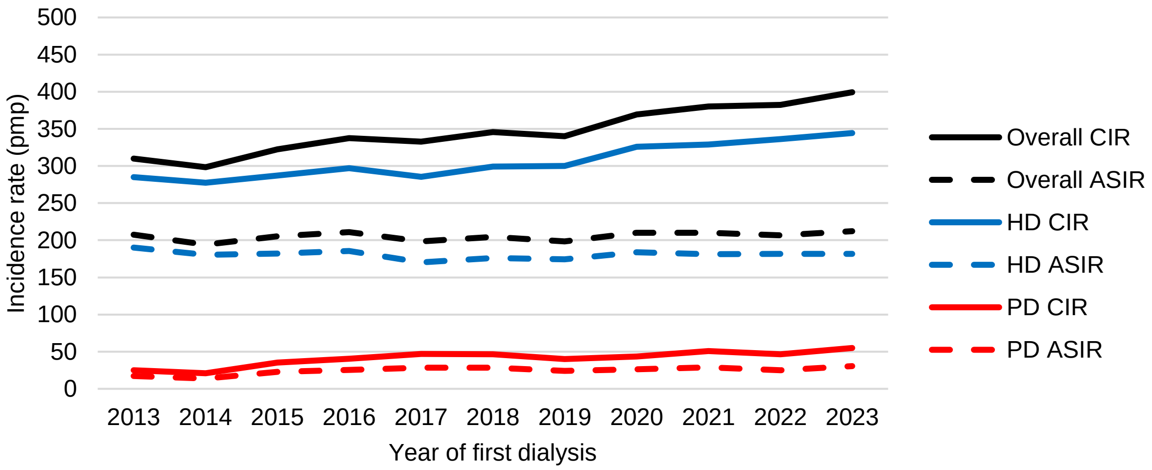
The ASIRs of ever-started dialysis were consistently higher among HD than PD, as about 90% of those who initiated dialysis did so with HD every year (Table 5.3.5, Figure 5.3.6). In 2023, the ASIR was 181.7 pmp and 30.5 pmp for HD and PD respectively. The Ministry of Health (MOH) has been working with the public healthcare institutions and dialysis service providers to promote the uptake of PD among local dialysis patients. While the ASIR for PD increased significantly over the years (p=0.011), the ASIR for HD remained stable.

Table 5.3.5: Incidence number and rate (pmp) of ever-started dialysis by modality

	HD			
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	1095	91.9	284.8	190.2
2014	1074	93.0	277.5	180.3
2015	1120	89.0	287.0	182.3
2016	1169	88.0	297.2	185.6
2017	1132	85.8	285.4	170.2
2018	1195	86.5	299.2	176.1
2019	1208	88.2	300.0	174.6
2020	1318	88.2	325.9	183.8
2021	1312	86.6	329.1	181.2
2022	1369	87.9	336.1	181.6
2023	1429	86.2	344.4	181.7
P for trend	-	-	<0.001**	0.534

PD				
Year of first dialysis	Number	%	CIR	ASIR
2013	96	8.1	25.0	17.2
2014	81	7.0	20.9	13.8
2015	138	11.0	35.4	22.9
2016	159	12.0	40.4	25.4
2017	187	14.2	47.2	28.4
2018	186	13.5	46.6	28.4
2019	162	11.8	40.2	24.0
2020	176	11.8	43.5	26.3
2021	203	13.4	50.9	28.7
2022	189	12.1	46.4	25.0
2023	228	13.8	54.9	30.5
P for trend	-	-	0.002**	0.011*

Figure 5.3.6: Incidence rate (pmp) of ever-started dialysis by modality



5.4 Incidence of definitive dialysis

The incidence rate of definitive dialysis in each year was calculated by taking the number of new patients who survived >90 days after initiation of dialysis in a year, divided by the number of Singapore residents in the same year. The modality was based on the dialysis closest to the 91st day from initiation of dialysis. As some patients did not survive beyond three months from the first dialysis, those on definitive dialysis is a more stable subset of the CKD5 and ever-started dialysis cohorts. Patients were categorised into 10-year age groups and age standardisation was done using the direct method with the Segi World population as the reference population.

The number of new patients on definitive dialysis increased by 55% from 978 in 2013 to 1,518 in 2023 (Table 5.4.1, Figure 5.4.1). Correspondingly, the CIR increased significantly from 254.4 pmp in 2013 to 365.8 pmp in 2023 ($p<0.001$). The rise in ASIR from 171.2 pmp in 2013 to 194.0 pmp in 2023 was also significant ($p=0.001$), suggesting that there were other factors besides population ageing that may account for the increase in dialysis incidence in Singapore. In contrast, in Taiwan, which has the highest incidence and prevalence of CKD5 in the world, the crude incidence of dialysis was noted to have increased significantly between 2010-2018, but the age-standardised incidence remained stable, suggesting that the increases in overall incidence was largely due to population ageing[14].

The 2019 Global Kidney Health Atlas (GKHA) cross-sectional survey of 160 nations showed that the incidence of treated CKD5[15] is much higher among the developed countries in the West such as the United States and high-income East and Southeast Asian countries, likely due to the higher burden of risk factors associated with CKD such as diabetes, hypertension, obesity and glomerular diseases[16].

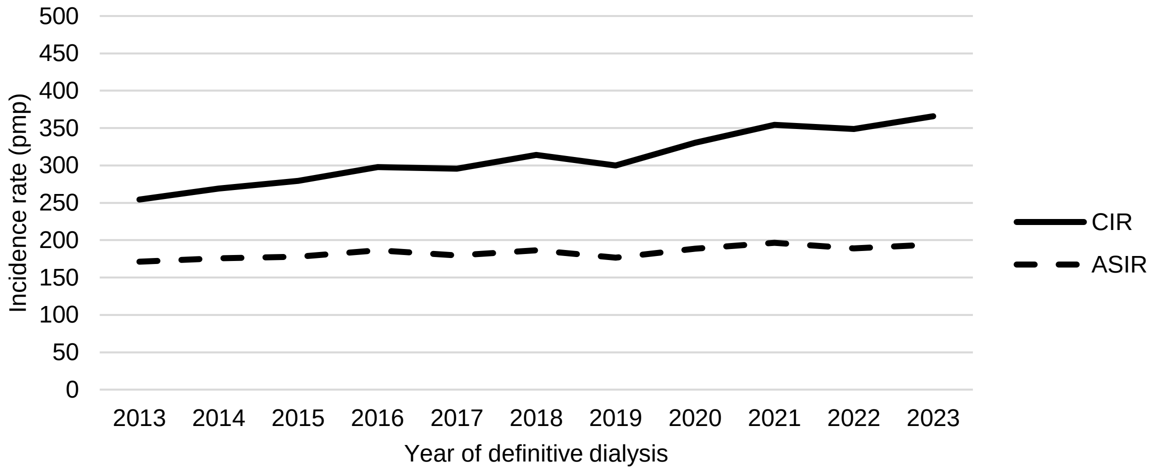
Likewise, according to data collected by the United States Renal Data System (USRDS), the incidence of treated CKD5 in Asia was noted to be comparatively higher than other parts of the world. In 2021, Singapore had the fifth highest incidence of treated CKD5 in the world among countries included in the analysis, behind countries like Taiwan, Brunei, and the United States[17].

[14] Lai et al. Trends in the incidence and prevalence of end-stage kidney disease requiring dialysis in Taiwan: 2010-2018. Journal of the Formosan Medical Association 2022; 121: S5-S11
[15] Refers to CKD5 treated with either dialysis or kidney transplant, with the former as the predominant form of treatment
[16] Thurlow J S et al. Global Epidemiology of End-Stage Kidney Disease and Disparities in Kidney Replacement Therapy. Am J Nephrol 2021;52:98–107.
[17] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2023/end-stage-renal-disease/11-international-comparisons. Accessed 29 September 2024.

Table 5.4.1: Incidence number and rate (pmp) of definitive dialysis

Year of definitive dialysis	Number	CIR	ASIR
2013	978	254.4	171.2
2014	1041	268.9	175.9
2015	1091	279.5	177.8
2016	1171	297.7	186.4
2017	1173	295.8	179.4
2018	1254	313.9	186.3
2019	1208	300.0	176.5
2020	1336	330.3	188.6
2021	1413	354.4	196.5
2022	1421	348.9	189.2
2023	1518	365.8	194.0
P for trend	-	<0.001**	0.001**

Figure 5.4.1: Incidence rate (pmp) of definitive dialysis



The age-specific incidence rate of definitive dialysis increased significantly for those aged 30-39 years (p=0.002), 40-49 years (p=0.026), 60-69 years (p=0.030), and 70-79 years (p=0.001) (Table 5.4.2). The majority of incident dialysis patients were found among the older age bands, especially those 60 years and above – increasing from 52.9% in 2013 to 69.3% in 2023. Data from the USRDS also showed that growth of incident treated CKD5[18] was highest among the older age bands (65-74 years, 75 years and above) across different countries[19]. The increase in age-specific incidence of dialysis among older age groups could be a result of polypharmacy among the elderly, where the high risk of exposure to the adverse effects from medications and procedures increases the risk of acute kidney injury and CKD progression to dialysis[20].

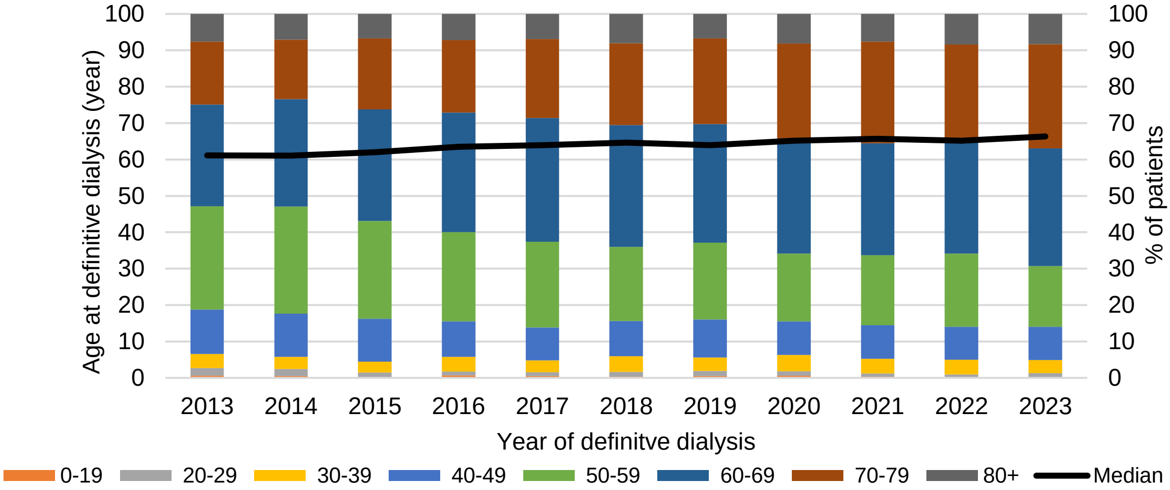
[18] Refers to CKD5 treated with either dialysis or kidney transplant, with the former as the predominant form of treatment
[19] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2023/end-stage-renal-disease/11-international-comparisons. Accessed 29 September 2024.
[20] Lai et al. Trends in the incidence and prevalence of end-stage kidney disease requiring dialysis in Taiwan: 2010-2018. Journal of the Formosan Medical Association 2022; 121: S5-S11

Table 5.4.2: Age distribution (%) and age-specific incidence rate (pmp) of definitive dialysis

Year of definitive dialysis	Age 0-19			Age 20-29			Age 30-39			Age 40-49		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2013	6	0.6	6.9	20	2.0	38.3	38	3.9	63.1	120	12.3	190.8
2014	5	0.5	5.8	20	1.9	37.8	35	3.4	58.9	124	11.9	198.5
2015	2	0.2	2.4	14	1.3	26.2	33	3.0	55.8	128	11.7	206.4
2016	8	0.7	9.6	12	1.0	22.2	48	4.1	81.7	114	9.7	185.5
2017	6	0.5	7.3	12	1.0	21.8	38	3.2	65.5	107	9.1	174.0
2018	4	0.3	4.9	17	1.4	31.1	54	4.3	92.3	121	9.6	197.9
2019	6	0.5	7.4	17	1.4	31.6	45	3.7	75.7	126	10.4	205.7
2020	8	0.6	10.0	16	1.2	30.1	60	4.5	100.4	123	9.2	201.3
2021	5	0.4	6.4	12	0.8	23.3	57	4.0	96.6	130	9.2	219.3
2022	0	0.0	0.0	13	0.9	25.3	58	4.1	95.4	129	9.1	213.5
2023	2	0.1	2.5	17	1.1	33.5	55	3.6	88.2	139	9.2	226.9
P for trend	-	-	0.689	-	-	0.467	-	-	0.002**	-	-	0.026*
Year of definitive dialysis	**Age 50-59**			**Age 60-69**			**Age 70-79**			**Age 80+**		
	Number	**%**	**CIR**	**Number**	**%**	**CIR**	**Number**	**%**	**CIR**	**Number**	**%**	**CIR**
2013	277	28.3	466.4	273	27.9	741.6	170	17.4	965.4	74	7.6	901.3
2014	306	29.4	506.7	307	29.5	781.8	170	16.3	928.4	74	7.1	847.7
2015	293	26.9	480.2	335	30.7	792.1	213	19.5	1158.6	73	6.7	781.2
2016	287	24.5	466.5	385	32.9	855.8	233	19.9	1215.1	84	7.2	858.9
2017	276	23.5	449.2	398	33.9	852.9	255	21.7	1206.0	81	6.9	799.8
2018	255	20.3	415.7	420	33.5	868.1	282	22.5	1232.1	101	8.1	945.0
2019	255	21.1	419.1	393	32.5	785.8	285	23.6	1164.6	81	6.7	700.3
2020	249	18.6	413.7	421	31.5	819.0	350	26.2	1341.0	109	8.2	879.2
2021	272	19.2	465.6	435	30.8	839.8	394	27.9	1446.9	108	7.6	822.5
2022	285	20.1	480.8	447	31.5	834.1	370	26.0	1256.9	119	8.4	876.1
2023	253	16.7	419.5	491	32.3	888.2	435	28.7	1364.1	126	8.3	900.6
P for trend	-	-	0.127	-	-	0.030*			0.001**	-	-	0.835

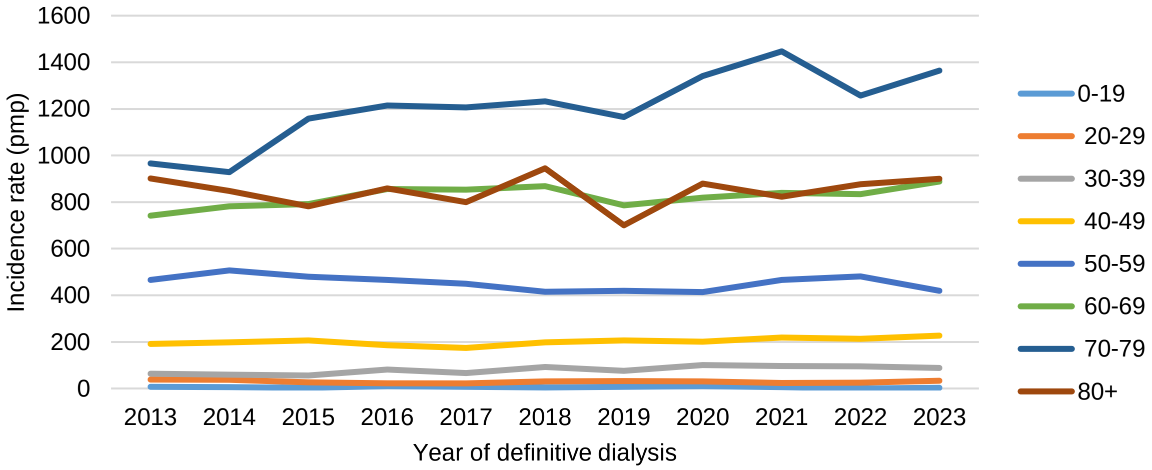
The median age at definitive dialysis increased from 61.1 years in 2013 to 66.3 years in 2023 ($p<0.001$) (Figure 5.4.2a).

Figure 5.4.2a: Median age (years) and age distribution (%) of new definitive dialysis patients



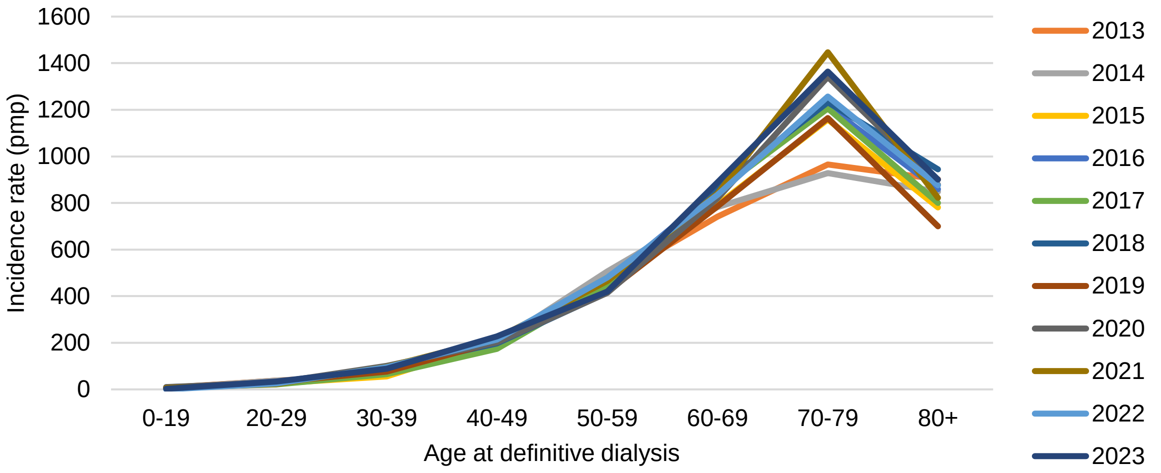
Similar to the trends for ever-started dialysis incidence (Table 5.3.1, Figure 5.3.1), the age-specific incidence rates of definitive dialysis increased with age (Figure 5.4.2b, Figure 5.4.3) It peaked for those aged 70 to 79 years, and then declined for those aged 80 years or older as studies have shown that dialysis offers little advantage in improving survival, especially among elderly patients with pre-existing co-morbidities[21].

Figure 5.4.2b: Age-specific incidence rate (pmp) of definitive dialysis across years



[21] Sarbjit V and Watson D. Dialysis in late life: benefit or burden. Clinical Journal of American Society of Nephrology. 2009; 4: 2008-2012.

Figure 5.4.3: Age-specific incidence rate (pmp) of definitive dialysis across age groups



Dialysis was more common among males than females, with males accounting for close to 60% of dialysis patients every year from 2013-2023. The ASIRs of definitive dialysis were consistently higher among males than females across the years (Table 5.4.3, Figure 5.4.4). In 2023, the ASIR was 239.7 pmp and 152.4 pmp for males and females respectively. The ASIR increased significantly over the years for males ($p<0.001$), but not for females ($p=0.615$). Like trends found in other high-income countries, males had a 1.2- to 1.5-fold higher incidence of dialysis across the years[22]. This could be due to higher prevalence of risk factors for CKD5 among males. For example, males are known to be at higher risk for developing diabetic kidney failure[23]. Hypertension also is a major risk factor for CKD5. The ASIR of hypertension-related CKD5 is higher in males than in females, both globally and in high-income countries[24].

Table 5.4.3: Incidence number and rate (pmp) of definitive dialysis by sex

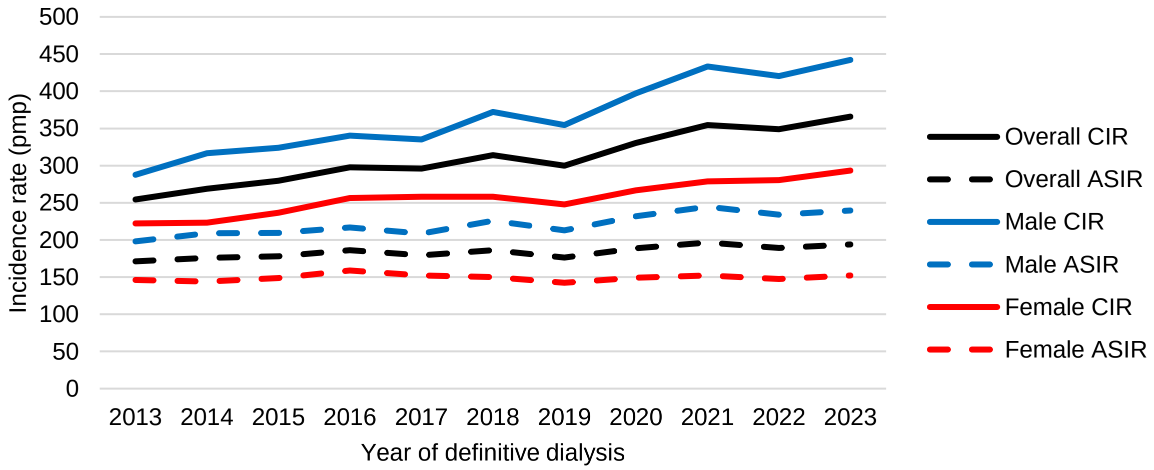
Male				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	544	55.6	287.6	198.1
2014	602	57.8	316.4	209.2
2015	621	56.9	324.0	209.6
2016	657	56.1	340.5	216.6
2017	651	55.5	335.0	208.4
2018	728	58.1	372.2	225.8
2019	698	57.8	354.4	213.0
2020	785	58.8	397.0	231.7
2021	846	59.9	433.2	244.6
2022	837	58.9	420.6	234.2

[22] Himmelfarb J, Vanholder R, Mehrotra R, and Tonelli M. The current and future landscape of dialysis. Nephrology. 2020;16.
[23] Hoogeveen E. K. The Epidemiology of Diabetic Kidney Disease. Kidney Dial. 2022, 2(3), 433-442
[24] Liu, Y., He, Q., Li, Q., & others. (2023). Global incidence and death estimates of chronic kidney disease due to hypertension from 1990 to 2019: An ecological analysis of the global burden of diseases 2019 study. *BMC Nephrology, 24*(352). https://doi.org/10.1186/s12882-023-03391-z

2023	894	58.9	442.2	239.7
P for trend	-	-	<0.001**	<0.001**

	Female			
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	434	44.4	222.2	146.2
2014	439	42.2	223.0	144.1
2015	470	43.1	236.6	148.6
2016	514	43.9	256.5	158.9
2017	522	44.5	258.1	152.3
2018	526	41.9	258.0	150.0
2019	510	42.2	248.0	142.4
2020	551	41.2	266.6	149.1
2021	567	40.1	278.8	152.0
2022	584	41.1	280.4	147.4
2023	624	41.1	293.3	152.4
P for trend	-	-	<0.001**	0.615

Figure 5.4.4: Incidence rate (pmp) of definitive dialysis by sex

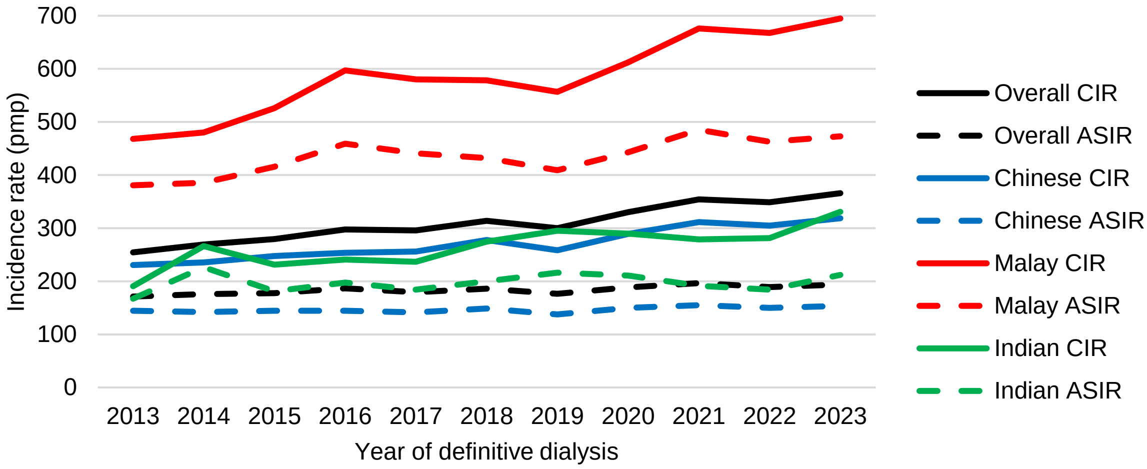


The ASIRs of definitive dialysis were consistently higher among Malays than Chinese and Indians across the years (Table 5.4.4, Figure 5.4.5). In 2023, the ASIR was 153.4 pmp, 472.9 pmp and 212.2 pmp for Chinese, Malays and Indians respectively. While the ASIRs for Malays (p=0.003) and Chinese (p=0.034) increased significantly over the years, the ASIR for Indians remained stable.

Table 5.4.4: Incidence number and rate (pmp) of definitive dialysis by ethnicity

Chinese				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	658	67.3	230.6	144.6
2014	677	65.0	235.5	141.9
2015	717	65.7	247.2	144.4
2016	742	63.4	253.8	144.6
2017	754	64.3	255.7	141.6
2018	825	65.8	277.8	148.6
2019	774	64.1	258.5	137.6
2020	869	65.0	289.0	149.9
2021	921	65.2	311.1	154.9
2022	920	64.7	304.7	149.9
2023	979	64.5	318.7	153.4
P for trend	-	-	<0.001**	0.034*
Malay				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	240	24.5	468.1	380.7
2014	248	23.8	480.0	385.5
2015	274	25.1	526.0	415.8
2016	314	26.8	597.1	459.3
2017	308	26.3	580.4	441.0
2018	310	24.7	578.5	432.2
2019	301	24.9	556.6	408.8
2020	334	25.0	612.3	443.0
2021	368	26.0	675.9	485.2
2022	370	26.0	667.7	462.8
2023	390	25.7	694.8	472.9
P for trend	-	-	<0.001**	0.003**
Indian				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	67	6.9	190.6	167.1
2014	94	9.0	266.3	226.4
2015	82	7.5	231.0	181.4
2016	86	7.3	241.0	197.5
2017	85	7.2	236.9	184.2
2018	99	7.9	274.6	200.2
2019	107	8.9	295.1	216.5
2020	105	7.9	289.8	210.7
2021	99	7.0	279.0	191.2
2022	103	7.2	281.1	184.5
2023	124	8.2	330.8	212.2
P for trend	-	-	0.002**	0.414

Figure 5.4.5: Incidence rate (pmp) of definitive dialysis by ethnicity



HD was the primary modality undertaken by individuals on dialysis in Singapore, ranging from 77.1% to 86.8% each year from 2013 to 2023 (Table 5.4.5). In Singapore, the MOH has been working with public hospitals and the social service sector to encourage PD utilisation among patients requiring dialysis by providing stakeholders with training to enable patients to independently perform PD at home[25]. The percentage of patients on definitive dialysis utilising HD has fallen over years, while that of PD has increased correspondingly. Nevertheless, the ASIRs of definitive dialysis remained consistently higher among HD than PD across the years (Table 5.4.5, Figure 5.4.6). In 2023, the ASIR was 150.1 pmp and 44.0 pmp for HD and PD respectively. For both modalities, no significant changes in ASIR were observed (HD: p=0.115; PD: p=0.060).

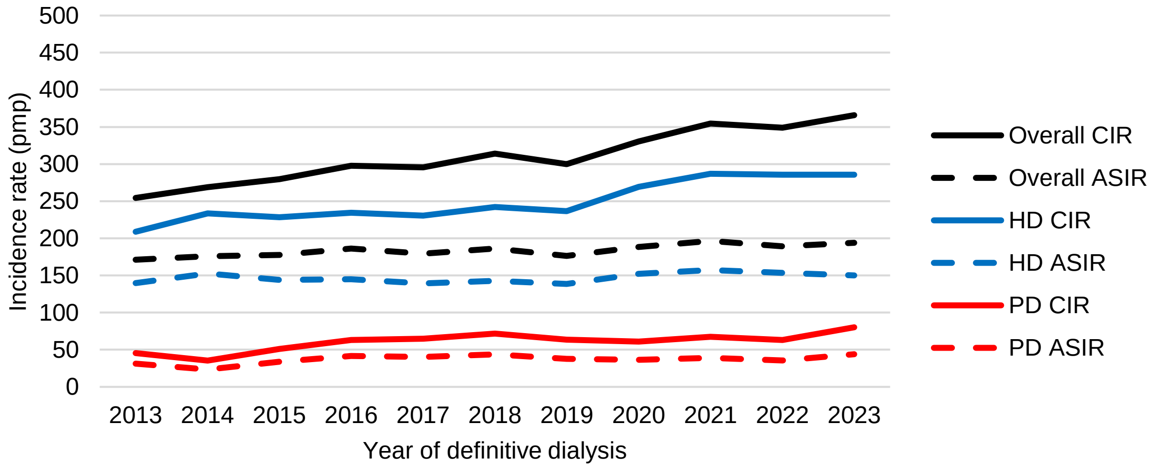
Table 5.4.5: Incidence number and rate (pmp) of definitive dialysis by modality

	HD			
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	803	82.1	208.9	139.8
2014	904	86.8	233.5	152.5
2015	891	81.7	228.3	143.9
2016	922	78.7	234.4	144.9
2017	915	78.0	230.7	139.3
2018	967	77.1	242.1	142.6
2019	952	78.8	236.4	138.6
2020	1090	81.6	269.5	152.1
2021	1144	81.0	286.9	157.3
2022	1163	81.8	285.5	153.6
2023	1185	78.1	285.6	150.1
P for trend	-	-	<0.001**	0.115

[25] Speech By Mr Ong Ye Kung, Minister For Health, At The 19th International Society For Peritoneal Dialysis Congress 2022 Opening Ceremony. Ministry of Health, Singapore. https://www.moh.gov.sg/news-highlights/details/speech-by-mr-ong-ye-kung-minister-for-health-at-the-19th-international-society-for-peritoneal-dialysis-congress-2022-opening-ceremony Accessed on 24 October 2023.

PD				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2013	175	17.9	45.5	31.4
2014	137	13.2	35.4	23.4
2015	200	18.3	51.2	33.9
2016	249	21.3	63.3	41.5
2017	258	22.0	65.1	40.1
2018	287	22.9	71.9	43.7
2019	256	21.2	63.6	37.9
2020	246	18.4	60.8	36.5
2021	269	19.0	67.5	39.2
2022	258	18.2	63.3	35.6
2023	333	21.9	80.3	44.0
P for trend	-	-	0.005**	0.060

Figure 5.4.6: Incidence rate (pmp) of definitive dialysis by modality



Among new patients on definitive dialysis, DN was the major cause of CKD5, accounting for about 2 in 3 new dialysis patients every year, followed by GN (Table 5.4.6). In 2023, 63.0% of the new definitive dialysis patients had DN, while 12.9% had GN. According to data collected by the USRDS, in 2021, Singapore had the second highest proportion of incident treated CKD5[26] attributed to diabetes in the world[27].

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[26] Refers to CKD5 treated with either dialysis or kidney transplant, with the former as the predominant form of treatment

[27] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2023/end-stage-renal-disease/11-international-comparisons. Accessed 29 September 2024.

Table 5.4.6: Incidence number of definitive dialysis by etiology

Year of definitive dialysis	DN		GN		Others	
	Number	%	Number	%	Number	%
2013	637	65.1	156	16.0	185	18.9
2014	673	64.6	166	15.9	202	19.4
2015	727	66.6	177	16.2	187	17.1
2016	780	66.6	169	14.4	222	19.0
2017	789	67.3	173	14.7	211	18.0
2018	831	66.3	175	14.0	248	19.8
2019	825	68.3	139	11.5	244	20.2
2020	905	67.7	164	12.3	267	20.0
2021	944	66.8	180	12.7	289	20.5
2022	917	64.5	182	12.8	322	22.7
2023	956	63.0	196	12.9	366	24.1

5.5 Prevalence of definitive dialysis

The prevalence rate of definitive dialysis in each year was calculated by taking the cumulative number of surviving (existing and new) definitive dialysis patients in a year, divided by the number of Singapore residents in the same year. Only patients surviving >90 days after initiation of dialysis were included. The modality was based on the last dialysis in each year. Patients were categorised into 10-year age groups and age standardisation was done using the direct method with the Segi World population as the reference population.

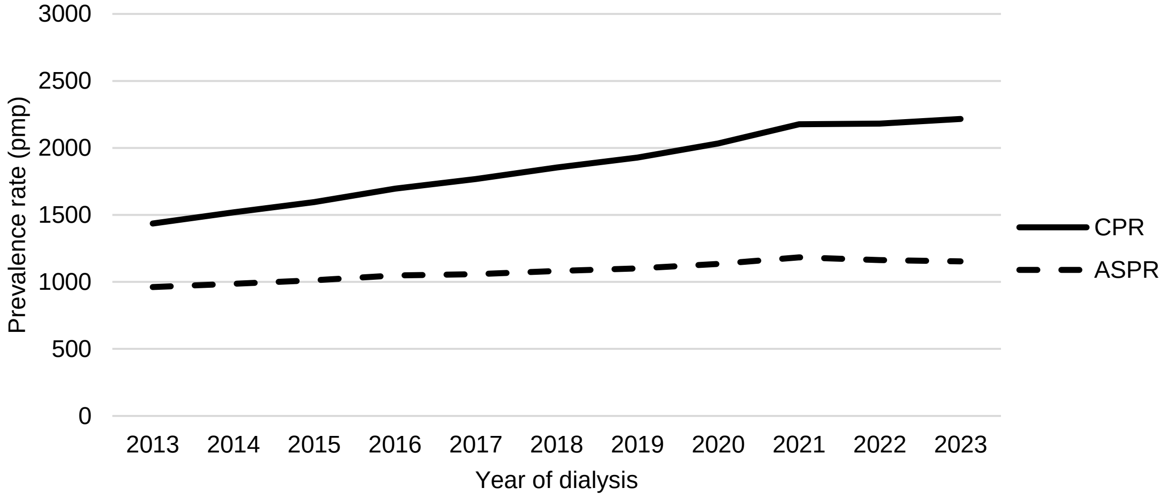
Like the incidence trends of definitive dialysis (Table 5.4.1, Figure 5.4.1), the number of prevalent patients on definitive dialysis increased consistently since 2013 (Table 5.5.1, Figure 5.5.1). Correspondingly, both the crude prevalence rate (CPR, $p<0.001$) and ASPR ($p<0.001$) increased significantly over the years. At the end of 2023, there were a total of 9,196 surviving dialysis patients, close to a 70% increase compared to 5,521 dialysis patients a decade ago. The CPR of definitive dialysis was 2,216.3 pmp and ASPR was 1,1154.3 pmp in 2023. The rise in ASPR suggests that the rise in new patients undergoing definitive dialysis was faster than the drop from those who died, even after adjusting for Singapore's ageing population. Data from USRDS indicated that in 2021, Singapore had the second highest prevalence of dialysis, as well as the third highest average yearly rate of change in dialysis prevalence from 2011 to 2021[28].

Table 5.5.1: Prevalence number and rate (pmp) of definitive dialysis

Year of dialysis	Number	CPR	ASPR
2013	5521	1436.1	961.8
2014	5879	1518.8	986.9
2015	6231	1596.6	1012.2
2016	6674	1696.7	1048.6
2017	7008	1767.1	1059.0
2018	7407	1854.4	1081.8
2019	7766	1928.9	1101.3
2020	8222	2033.0	1133.9
2021	8675	2175.9	1183.4
2022	8885	2181.3	1162.9
2023	9196	2216.3	1154.3
P for trend	-	<0.001**	<0.001**

[28] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2023/end-stage-renal-disease/11-international-comparisons. Accessed 29 September 2024.

Figure 5.5.1: Prevalence rate (pmp) of definitive dialysis



The age-specific prevalence rate of definitive dialysis increased for all age bands aged 30 years and above, with those aged 30-39 registering the largest percentage change (p<0.001) (Table 5.5.2). Nevertheless, older individuals comprised the majority of prevalent dialysis patients. In 2023, 70.5% of prevalent dialysis patients were aged 60 and above.

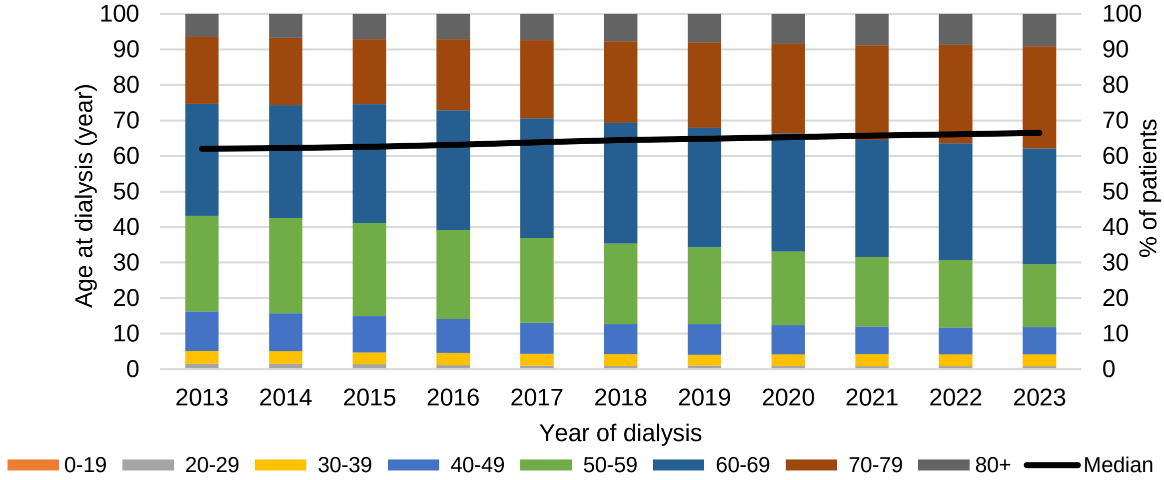
Table 5.5.2: Age distribution (%) and age-specific prevalence rate (pmp) of definitive dialysis

Year of dialysis	Age 0-19			Age 20-29			Age 30-39			Age 40-49		
	Number	%	CPR	Number	%	CPR	Number	%	CPR	Number	%	CPR
2013	13	0.2	14.9	73	1.3	139.7	198	3.6	328.7	611	11.1	971.7
2014	12	0.2	14.0	75	1.3	141.6	207	3.5	348.3	629	10.7	1007.1
2015	12	0.2	14.2	70	1.1	130.8	210	3.4	354.9	639	10.3	1030.4
2016	13	0.2	15.6	67	1.0	123.9	225	3.4	383.0	637	9.5	1036.4
2017	12	0.2	14.5	55	0.8	100.1	235	3.4	405.0	611	8.7	993.6
2018	13	0.2	15.9	51	0.7	93.2	250	3.4	427.3	621	8.4	1015.6
2019	14	0.2	17.2	59	0.8	109.8	242	3.1	407.2	668	8.6	1090.7
2020	19	0.2	23.6	55	0.7	103.5	267	3.2	447.0	674	8.2	1103.1
2021	18	0.2	23.0	54	0.6	104.7	291	3.4	493.0	679	7.8	1145.2
2022	13	0.1	16.5	61	0.7	118.8	294	3.3	483.4	674	7.6	1115.5
2023	12	0.1	15.2	64	0.7	126.2	308	3.3	493.9	701	7.6	1144.1
P for trend	-	-	0.091	-	-	0.153	-	-	<0.001**	-	-	<0.001**

Year of dialysis	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CPR	Number	%	CPR	Number	%	CPR	Number	%	CPR
2013	1490	27.0	2508.8	1739	31.5	4724.3	1046	18.9	5939.8	351	6.4	4275.3
2014	1577	26.8	2611.4	1871	31.8	4764.5	1110	18.9	6062.0	398	6.8	4559.3
2015	1634	26.2	2678.0	2085	33.5	4930.0	1141	18.3	6206.4	440	7.1	4708.5
2016	1672	25.1	2717.9	2250	33.7	5001.4	1336	20.0	6967.4	474	7.1	4846.7
2017	1673	23.9	2722.6	2363	33.7	5064.1	1542	22.0	7292.6	517	7.4	5104.9
2018	1685	22.7	2747.2	2519	34.0	5206.8	1693	22.9	7397.1	575	7.8	5379.9
2019	1677	21.6	2756.2	2623	33.8	5244.7	1860	24.0	7600.3	623	8.0	5386.6
2020	1707	20.8	2836.0	2734	33.3	5318.8	2077	25.3	7957.9	689	8.4	5557.6
2021	1699	19.6	2908.3	2857	32.9	5515.4	2314	26.7	8497.9	763	8.8	5810.5
2022	1690	19.0	2850.8	2920	32.9	5448.4	2456	27.6	8343.1	777	8.7	5720.5
2023	1627	17.7	2698.0	3001	32.6	5428.4	2644	28.8	8291.2	839	9.1	5996.8
P for trend	-	-	0.005**	-	-	<0.001**	-	-	<0.001**	-	-	<0.001**

The median age among prevalent definitive dialysis patients increased from 62.0 years in 2013 to 66.5 years in 2023 (p<0.001) (Figure 5.5.2a).

Figure 5.5.2a: Median age (years) and age distribution (%) of prevalent definitive dialysis patients



Similar to the trends observed for dialysis incidence (Figure 5.4.2b, Figure 5.4.3), the age-specific prevalence rate of definitive dialysis increased with age, and it peaked for those aged 70 to 79 years (Figure 5.5.2b, Figure 5.5.3).

Figure 5.5.2b: Age-specific prevalence rate (pmp) of definitive dialysis across years

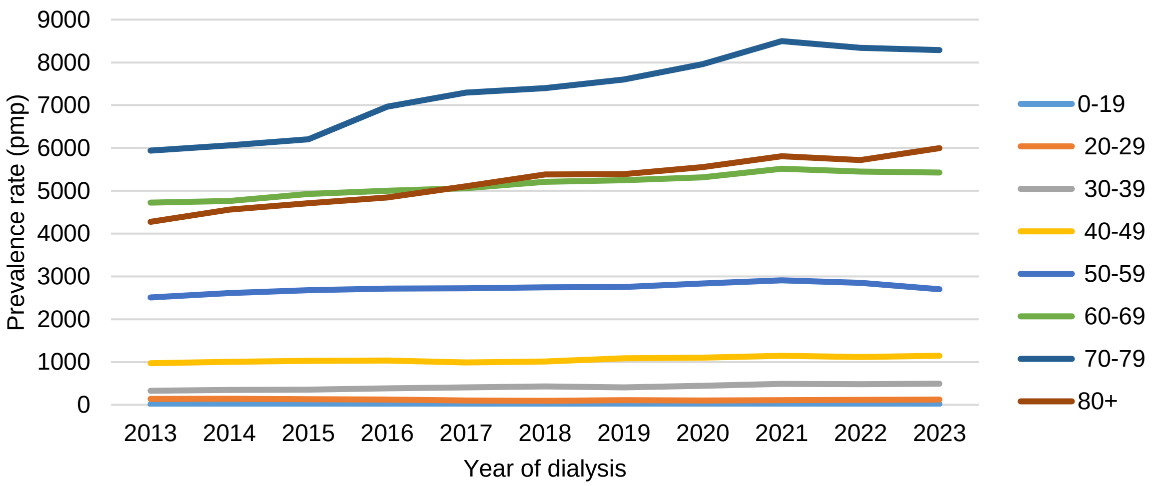
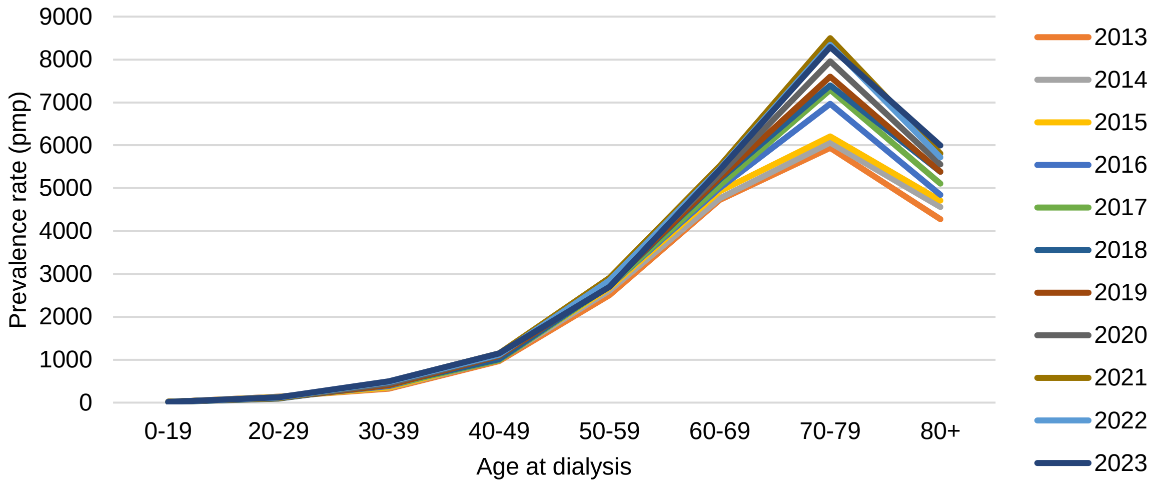


Figure 5.5.3: Age-specific prevalence rate (pmp) of definitive dialysis across age groups



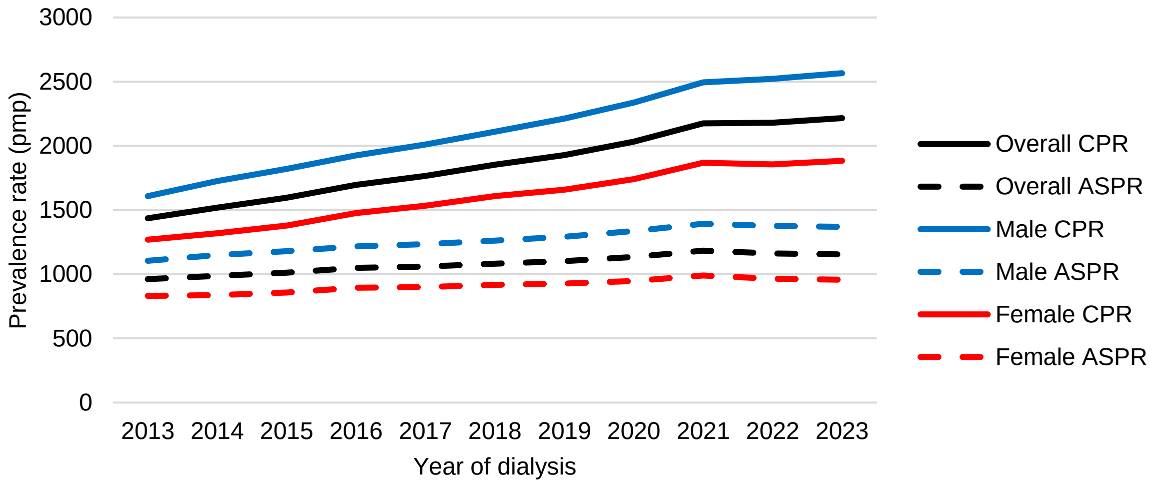
Akin to the trends for dialysis incidence (Table 5.4.3, Figure 5.4.4), males comprised a higher percentage of prevalent dialysis patients, and the ASPRs of definitive dialysis were consistently higher among males than females across the years (Table 5.5.3, Figure 5.5.4). In 2023, the ASPR was 1,369.6 pmp and 957.7 pmp for males and females respectively. The ASPRs for both sexes increased significantly over the years (p<0.001), with a larger rise for males.

Table 5.5.3: Prevalence number and rate (pmp) of definitive dialysis by sex

Male				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2013	3042	55.1	1608.4	1104.7
2014	3283	55.8	1725.7	1149.8
2015	3490	56.0	1820.9	1180.3
2016	3714	55.6	1924.8	1217.8
2017	3906	55.7	2009.7	1234.4
2018	4127	55.7	2110.1	1261.3
2019	4356	56.1	2211.9	1291.1
2020	4624	56.2	2338.2	1336.4
2021	4875	56.2	2496.0	1393.1
2022	5021	56.5	2522.8	1377.2
2023	5189	56.4	2566.4	1369.6
P for trend	-	-	<0.001**	<0.001**

Female				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2013	2479	44.9	1269.3	831.0
2014	2596	44.2	1318.9	836.8
2015	2741	44.0	1380.1	857.1
2016	2960	44.4	1477.0	893.6
2017	3102	44.3	1533.9	899.0
2018	3280	44.3	1609.1	918.0
2019	3410	43.9	1657.9	928.2
2020	3598	43.8	1741.0	947.8
2021	3800	43.8	1868.5	990.0
2022	3864	43.5	1855.0	965.6
2023	4007	43.6	1883.6	957.7
P for trend	-	-	<0.001**	<0.001**

Figure 5.5.4: Prevalence rate (pmp) of definitive dialysis by sex

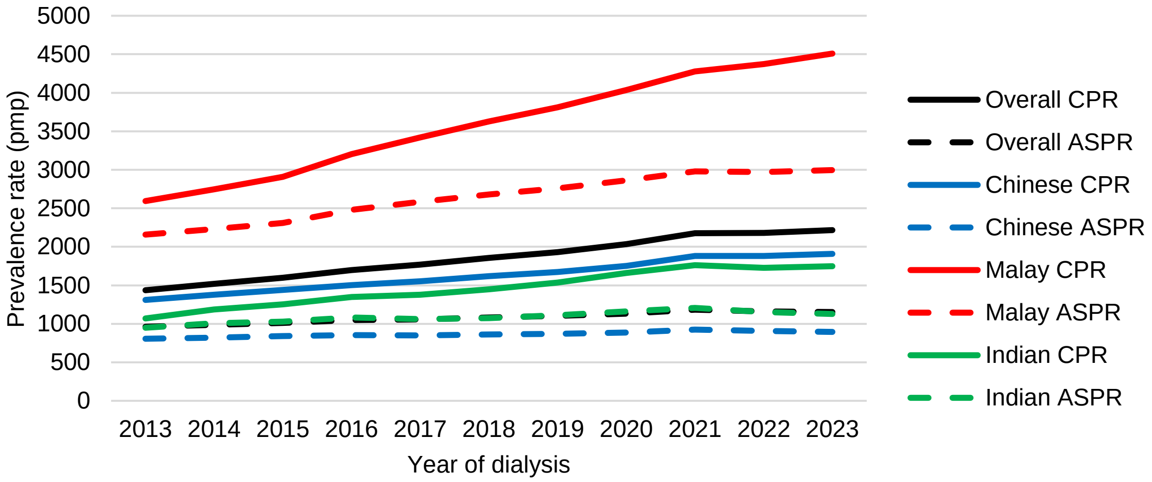


The ASPRs of definitive dialysis were consistently higher among Malays than Chinese and Indians across the years (Table 5.5.4, Figure 5.5.5). In 2023, the ASPR was 896.8 pmp, 2,995.6 pmp and 1,129.8 pmp for Chinese, Malays and Indians respectively. While the ASPRs for all the three ethnic groups increased significantly over the years ($p<0.001$), the increment for Malays was higher than those for Chinese and Indians.

Table 5.5.4: Prevalence number and rate (pmp) of definitive dialysis by ethnicity

Chinese				
Year of dialysis	Number	%	CPR	ASPR
2013	3739	67.7	1310.2	806.1
2014	3954	67.3	1375.6	821.1
2015	4178	67.1	1440.7	840.0
2016	4397	65.9	1504.2	853.3
2017	4572	65.2	1550.7	849.2
2018	4805	64.9	1618.2	860.2
2019	5005	64.4	1671.8	868.4
2020	5268	64.1	1752.0	888.5
2021	5572	64.2	1882.3	924.8
2022	5683	64.0	1882.4	907.0
2023	5863	63.8	1908.3	896.8
P for trend	-	-	<0.001**	<0.001**
Malay				
Year of dialysis	Number	%	CPR	ASPR
2013	1330	24.1	2594.1	2158.3
2014	1418	24.1	2744.6	2231.2
2015	1516	24.3	2910.2	2309.0
2016	1685	25.2	3204.1	2479.1
2017	1815	25.9	3419.9	2584.0
2018	1945	26.3	3629.9	2679.7
2019	2062	26.6	3813.0	2758.6
2020	2202	26.8	4036.7	2861.4
2021	2328	26.8	4275.9	2981.0
2022	2422	27.3	4371.0	2972.8
2023	2531	27.5	4508.9	2995.6
P for trend	-	-	<0.001**	<0.001**
Indian				
Year of dialysis	Number	%	CPR	ASPR
2013	376	6.8	1069.7	949.0
2014	419	7.1	1186.9	1005.9
2015	444	7.1	1250.9	1030.0
2016	481	7.2	1347.8	1080.4
2017	494	7.0	1376.7	1061.6
2018	522	7.0	1447.9	1075.4
2019	557	7.2	1536.0	1109.9
2020	601	7.3	1659.0	1162.2
2021	625	7.2	1761.1	1206.2
2022	633	7.1	1727.6	1152.3
2023	655	7.1	1747.3	1129.8
P for trend	-	-	<0.001**	<0.001**

Figure 5.5.5: Prevalence rate (pmp) of definitive dialysis by ethnicity



HD was the predominant dialysis modality utilised by prevalent dialysis patients in Singapore, with almost 9 in 10 prevalent dialysis patients on HD every year (Table 5.5.5). This is similar to most countries worldwide, with HD accounting for the bulk of the dialysis undertaken[29]. Among countries with more than 95% of prevalent dialysis patients on HD were Greece, Poland, and Bangladesh[30], with Hong Kong offering an interesting contrast – its "PD-first" approach meant that about two-thirds of prevalent CKD5 patients were on PD in 2021 – the highest PD uptake rate in the world among countries included in the USRDS data[31,32]. Overall, HD is the most common form of renal replacement therapy (RRT) in the world, accounting for about 69% of all RRT and 89% of dialysis[33].

The ASPRs of definitive dialysis were consistently higher among HD than PD across the years (Table 5.5.5, Figure 5.5.6). In 2023, the ASPR was 989.7 pmp and 164.6 pmp for HD and PD respectively. The ASPRs for both HD and PD increased significantly over the years ($p<0.001$).

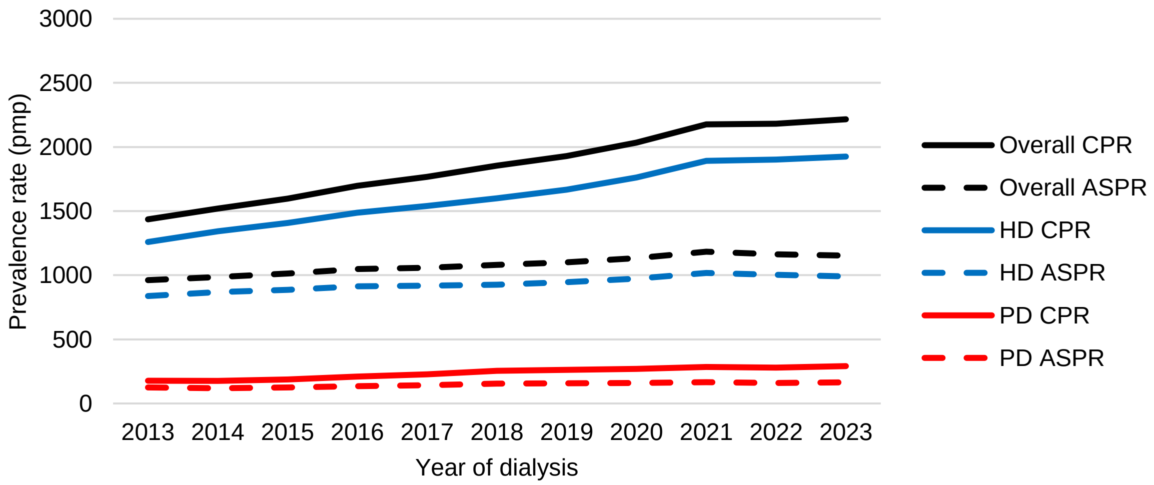
[29] Filipska A, Bohdan B, Wieczorek P and Hudz N. Chronic kidney disease and dialysis therapy: incidence and prevalence in the world. Pharmacia 68(2): 463–470.
[30] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2023/end-stage-renal-disease/11-international-comparisons. Accessed 29 September 2024.
[31] Ibid.
[32] Li KT. et al. Peritoneal dialysis first policy in Hong Kong for 35 years: Global impact. Nephrology. 2022;27:787–794.
[33] Bello AK et al. Epidemiology of haemodialysis outcomes. Nature 2022; 18.

Table 5.5.5: Prevalence number and rate (pmp) of definitive dialysis by modality

HD				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2013	4841	87.7	1259.2	837.8
2014	5198	88.4	1342.9	868.1
2015	5498	88.2	1408.8	886.9
2016	5851	87.7	1487.5	913.3
2017	6111	87.2	1540.9	917.9
2018	6389	86.3	1599.5	926.8
2019	6710	86.4	1666.6	944.9
2020	7129	86.7	1762.8	974.6
2021	7540	86.9	1891.2	1017.7
2022	7749	87.2	1902.4	1003.4
2023	7988	86.9	1925.2	989.7
P for trend	-	-	<0.001**	<0.001**

PD				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2013	680	12.3	176.9	124.0
2014	681	11.6	175.9	118.8
2015	733	11.8	187.8	125.3
2016	823	12.3	209.2	135.3
2017	897	12.8	226.2	141.1
2018	1018	13.7	254.9	155.0
2019	1056	13.6	262.3	156.3
2020	1093	13.3	270.3	159.3
2021	1135	13.1	284.7	165.7
2022	1136	12.8	278.9	159.6
2023	1208	13.1	291.1	164.6
P for trend	-	-	<0.001**	<0.001**

Figure 5.5.6: Prevalence rate (pmp) of definitive dialysis by modality



While about two-thirds of incident dialysis patients each year had DN (Table 5.4.6), a lower percentage (slightly more than half) of prevalent dialysis patients had the condition, likely due to poorer survival rates among dialysis patients with DN. The proportion of prevalent definitive dialysis patients with DN increased from 50.0% in 2013 to 55.4% in 2023 (Table 5.5.6). On the other hand, the proportion of prevalent definitive dialysis patients with GN dropped from 28.4% in 2013 to 21.4% in 2023. Similar to the situation in Singapore, diabetes is noted to be the most common cause of CKD5 worldwide[34].

Table 5.5.6: Prevalence number of definitive dialysis by etiology

Year of dialysis	DN		GN		Others	
	Number	%	Number	%	Number	%
2013	2761	50.0	1570	28.4	1190	21.6
2014	2999	51.0	1613	27.4	1267	21.6
2015	3273	52.5	1682	27.0	1276	20.5
2016	3570	53.5	1726	25.9	1378	20.6
2017	3803	54.3	1747	24.9	1458	20.8
2018	4065	54.9	1776	24.0	1566	21.1
2019	4291	55.3	1808	23.3	1667	21.5
2020	4609	56.1	1848	22.5	1765	21.5
2021	4885	56.3	1912	22.0	1878	21.6
2022	4979	56.0	1923	21.6	1983	22.3
2023	5098	55.4	1967	21.4	2131	23.2

[34] Filipska A, Bohdan B, Wieczorek P and Hudz N. Chronic kidney disease and dialysis therapy: incidence and prevalence in the world. Pharmacia 68(2): 463–470.

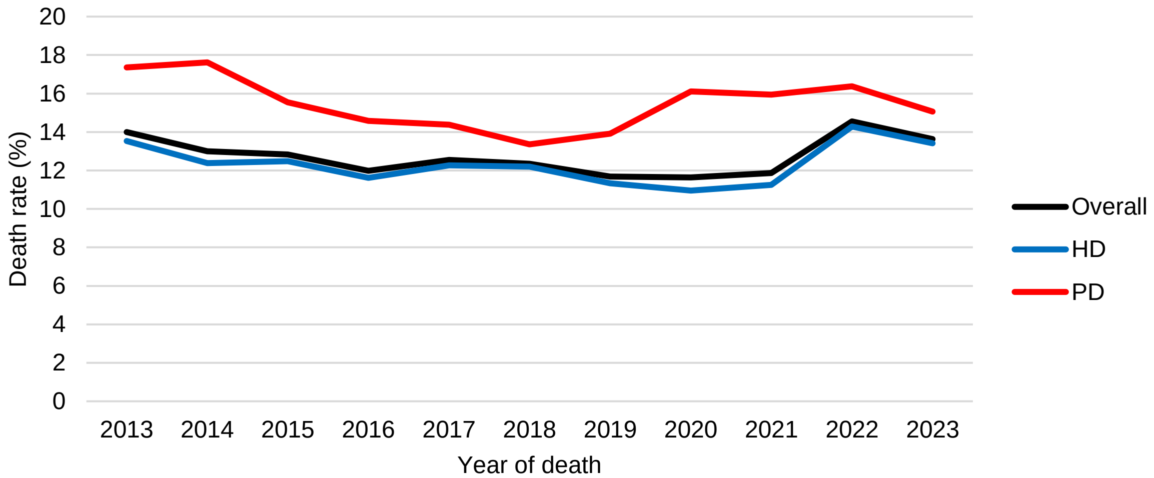
5.6 Mortality of definitive dialysis

In 2023, 13.6% of the patients on definitive dialysis died, similar to 14.0% a decade ago (Table 5.6.1, Figure 5.6.1). Based on the last modality that the dialysis patient received before death, a greater proportion of PD patients died compared to HD over the years. The disparity in mortality between HD and PD will be further examined in the next section.

Table 5.6.1: All-cause mortality by modality

Year of death	Overall		HD		PD	
	Number	%	Number	%	Number	%
2013	773	14.0	655	13.5	118	17.4
2014	764	13.0	644	12.4	120	17.6
2015	800	12.8	686	12.5	114	15.6
2016	800	12.0	680	11.6	120	14.6
2017	879	12.5	750	12.3	129	14.4
2018	915	12.4	779	12.2	136	13.4
2019	908	11.7	761	11.3	147	13.9
2020	957	11.6	781	11.0	176	16.1
2021	1030	11.9	849	11.3	181	15.9
2022	1293	14.6	1107	14.3	186	16.4
2023	1254	13.6	1072	13.4	182	15.1

Figure 5.6.1: All-cause mortality by modality



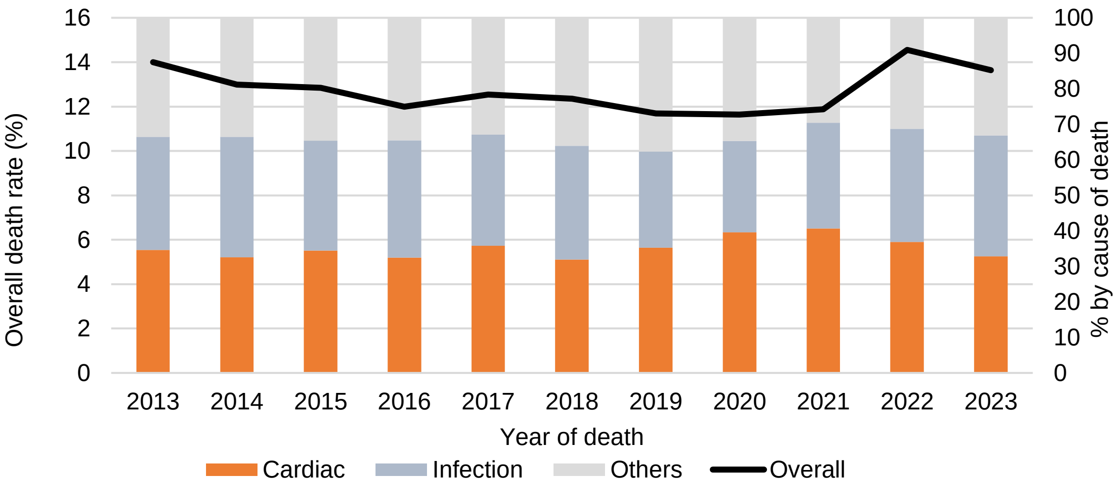
Deaths related to cardiac events and infection were the two most common causes of deaths among dialysis patients and each of them accounted for about a third of all deaths across the years (Table 5.6.2, Figure 5.6.2). The burden of cardiovascular risk factors among dialysis patients is noted to be markedly greater than that of the general population; and the risk of infection is also greater, driven in part by access-related infections in HD patients with central venous catheters as well as blood-borne virus infections such as hepatitis B and C, and peritonitis-related infections in PD patients[35,36].

Table 5.6.2: Mortality by cause of death

Year of death	Overall		Cardiac event		Infection		Others	
	Number	%*	Number	%^	Number	%^	Number	%^
2013	773	14.0	268	34.7	246	31.8	259	33.5
2014	764	13.0	249	32.6	259	33.9	256	33.5
2015	800	12.8	276	34.5	247	30.9	277	34.6
2016	800	12.0	260	32.5	264	33.0	276	34.5
2017	879	12.5	315	35.8	275	31.3	289	32.9
2018	915	12.4	292	31.9	293	32.0	330	36.1
2019	908	11.7	320	35.2	246	27.1	342	37.7
2020	957	11.6	379	39.6	246	25.7	332	34.7
2021	1030	11.9	419	40.7	307	29.8	304	29.5
2022	1293	14.6	477	36.9	412	31.9	404	31.2
2023	1254	13.6	412	32.9	426	34.0	416	33.2

*Mortality among prevalent dialysis patients
^Mortality among prevalent dialysis patients who died due to specific causes (e.g. cardiac event, infection)

Figure 5.6.2: Mortality by cause of death



[35] Himmelfarb J, Vanholder R, Mehrotra R, and Tonelli M. The current and future landscape of dialysis. Nephrology. 2020;16.
[36] Bello AK et al. Epidemiology of haemodialysis outcomes. Nature 2022; 18.

5.7 Survival of definitive dialysis

The unadjusted survival rate and median survival duration of new patients on definitive dialysis were estimated using the Kaplan-Meier method in Tables 5.7.2 to 5.7.11. Event was defined as all-cause death. Patients were censored if they stopped definitive dialysis (i.e. received kidney transplant), or reached the end of the follow-up period (i.e. neither received kidney transplant nor died by 30 April 2024, the date until which the death status of all patients were updated for this report). Survival at 5 or 10 years is indicated as “not applicable (NA)” if the elapsed survival time since dialysis initiation exceeds this date. Median survival duration is indicated as “not reached (NR)” if more than half of the patients were alive as of 30 April 2024. Multivariable Cox regression was used to estimate the adjusted risk of death, accounting for the effects of potential confounders in Table 5.7.12.

All analyses in this section were stratified by or adjusted for modality as the baseline characteristics (Table 5.7.1) and survival (Table 5.7.2) differed between HD and PD patients. The modality, age, sex, ethnicity, etiology and co-morbidities in this section were based on data captured by the registry at the start of definitive dialysis.

The baseline characteristics of HD and PD patients are shown in Table 5.7.1. Compared to PD patients, the proportion of males was higher ($p<0.001$), but the proportion of Chinese was lower ($p<0.001$) among HD patients (Table 5.7.1). The proportions of those with cerebrovascular disease ($p=0.004$) were higher among PD patients. However, higher proportions of HD patients had ischemic heart disease ($p=0.010$), peripheral vascular disease ($p<0.001$) and cancer ($p<0.001$).

Table 5.7.1: Baseline characteristics by modality

	HD	PD	Overall
Age group (%)			
≥60 years	56.9	57.6	57.1
Sex (%)			
Male	57.6	50.9	56.2
Ethnicity (%)			
Chinese	65.4	72.1	66.8
Malay	25.1	20.1	24.0
Indian	7.8	6.1	7.5
Etiology (%)			
DN	62.8	62.4	62.7
Co-morbidities (%)			
Ischemic heart disease	46.4	44.4	46.0
Cerebrovascular disease	23.3	25.2	23.7
Peripheral vascular disease	15.0	12.6	14.5
Cancer	9.3	5.1	8.4

HD patients had significantly better survival than PD patients as indicated by their higher survival rates at each time-point, and longer median survival duration ($p<0.001$) (Table 5.7.2).

Table 5.7.2: Survival of definitive dialysis by modality

	HD	PD	Overall
1-year survival (%)	90.9	90.5	90.9
5-year survival (%)	60.8	43.3	57.0
10-year survival (%)	31.8	20.3	29.3
Median survival (years)	6.6	4.3	6.0

Although 5- and 10-year survival were consistently better among HD than PD patients, differences in survival had narrowed over the years as the survival of HD patients were similar throughout the years ($p=0.201$), while the survival of PD patients improved over time ($p<0.001$) (Table 5.7.3). These findings mirror those found in another study which reported that long-term mortality risk was historically higher among PD patients, but over time, the reduction in mortality risk has been greater for PD compared to HD, such that the long-term survival of HD and PD patients are now similar[37]..

Table 5.7.3: Survival of definitive dialysis by year and modality

	1999-2003			2004-2008		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	90.4	85.3	88.7	89.6	87.3	89.1
5-year survival (%)	58.7	32.1	49.7	59.2	37.0	54.3
10-year survival (%)	33.2	14.8	26.9	31.1	17.2	28.1
Median survival (years)	6.5	3.3	4.9	6.4	3.7	5.6
	2009-2013			2014-2018		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	89.7	90.1	89.8	91.8	93.1	92.0
5-year survival (%)	59.3	46.5	57.1	61.6	50.2	59.3
10-year survival (%)	30.6	22.7	29.2	NA	NA	NA
Median survival (years)	6.3	4.6	6.0	6.5	5.0	6.2
	2019-2023					
	HD	PD	Overall			
1-year survival (%)	91.9	94.7	92.5			
5-year survival (%)	NA	NA	NA			
10-year survival (%)	NA	NA	NA			
Median survival (years)	NR	NR	NR			

For both HD and PD, younger patients aged below 60 years had significantly better survival than older patients aged 60 years and above ($p<0.001$) (Table 5.7.4).

[37] Himmelfarb J, Vanholder R, Mehrotra R, and Tonelli M. The current and future landscape of dialysis. Nephrology. 2020;16.

Table 5.7.4: Survival of definitive dialysis by age group and modality

	Age <60 years			Age ⩾60 years		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	93.8	94.0	93.8	88.8	88.0	88.7
5-year survival (%)	72.1	59.8	69.5	52.0	31.4	47.4
10-year survival (%)	46.1	35.4	43.9	19.7	9.1	17.3
Median survival (years)	9.1	6.6	8.7	5.3	3.4	4.7

Female HD patients had significantly better survival than male HD patients (p<0.001). However, there were no significant sex differences in survival for PD (p=0.626) (Table 5.7.5).

Table 5.7.5: Survival of definitive dialysis by sex and modality

	Male			Female		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	90.5	90.9	90.6	91.5	90.2	91.2
5-year survival (%)	59.8	44.4	56.8	62.1	42.2	57.3
10-year survival (%)	30.7	19.0	28.5	33.3	21.6	30.4
Median survival (years)	6.5	4.4	6.0	6.7	4.2	6.0

Malay HD patients had significantly better survival than Chinese and Indian HD patients (p<0.001) (Table 5.7.6). However, there were no significant ethnic differences in survival among PD patients.

Table 5.7.6: Survival of definitive dialysis by ethnicity and modality

	Chinese			Malay			Indian		
	HD	PD	Overall	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	91.0	90.7	90.9	91.3	90.1	91.1	90.0	89.7	89.9
5-year survival (%)	59.8	43.4	56.0	64.1	41.9	60.1	58.6	44.3	56.1
10-year survival (%)	30.8	19.6	28.2	35.6	22.5	33.2	27.4	19.8	26.1
Median survival (years)	6.4	4.3	5.8	7.1	4.1	6.5	6.0	4.1	5.8

Patients without DN had significantly better survival than those with DN regardless of modality (p<0.001) (Table 5.7.7). Population cohort studies have consistently shown that the presence of type 2 diabetes is associated with an excess risk of mortality in CKD5 patients[38]. Possible reasons include metabolic factors and accelerated vascular calcification. Poor glycaemic control, xerostomia (dry mouth) and thirst can also lead to fluid overload among diabetic HD patients, resulting in high rates of haemodynamic instability[39].

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[38] Phillips J, Chen J, Ooi E, Prunster J and Lim WH. Global Epidemiology, Health Outcomes, and Treatment Options for Patients With Type 2 Diabetes and Kidney Failure. Frontiers in Clinical Diabetes and Healthcare 2021; 2.
[39] Eldehni M, Crowley L, Selby N. Challenges in Management of Diabetic Patient on Dialysis. Kidney Dial. 2022; 2: 553–564.

Table 5.7.7: Survival of definitive dialysis by etiology and modality

	Non-DN			DN		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	92.5	94.1	92.8	90.1	88.4	89.7
5-year survival (%)	71.8	64.6	70.3	54.4	31.1	49.4
10-year survival (%)	48.8	39.3	46.8	21.6	9.6	19.0
Median survival (years)	9.8	7.5	9.2	5.5	3.4	4.9

Patients without ischemic heart disease (IHD) had significantly better survival than those with IHD regardless of modality ($p<0.001$) (Table 5.7.8). In a review looking at patients with both CKD5 and cardiovascular conditions like IHD, cardiovascular disease, rather than CKD5, emerged as the primary cause of death. CKD5 exacerbates IHD by promoting a systemic, chronic proinflammatory state, which contributes to vascular and myocardial remodelling. This results in atherosclerotic lesions, vascular calcification, myocardial fibrosis, etc, thereby potentially elevating mortality risk[40].

Table 5.7.8: Survival of definitive dialysis by presence of IHD and modality

	No IHD			IHD		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	93.1	93.5	93.2	88.8	87.1	88.4
5-year survival (%)	70.1	55.5	66.9	51.0	29.8	46.4
10-year survival (%)	42.7	30.3	40.1	19.8	9.8	17.7
Median survival (years)	8.5	5.7	7.9	5.1	3.3	4.6

Patients without cerebrovascular disease (CVD) had significantly better survival than those with CVD regardless of modality ($p<0.001$) (Table 5.7.9). A review examining patients with both CKD and stroke found that CKD significantly worsens stroke outcomes, potentially leading to functional brain damage and resulting in cognitive impairment. Cognitive dysfunction has been associated with poor medication adherence, which in turn is linked to increased morbidity and mortality [41].

Table 5.7.9: Survival of definitive dialysis by presence of CVD and modality

	No CVD			CVD		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	92.1	92.2	92.1	87.6	86.3	87.3
5-year survival (%)	64.7	48.9	61.4	49.2	28.8	44.4
10-year survival (%)	35.8	24.1	33.4	19.0	10.5	17.0
Median survival (years)	7.2	4.9	6.7	4.9	3.2	4.4

[40] Jankowski, J., Floege, J., Fliser, D., Böhm, M., & Marx, N. (2021). Cardiovascular disease in chronic kidney disease. Circulation, 143(11), 1157–1172. https://doi.org/10.1161/circulationaha.120.050686
[41] Miglinas, M., Cesniene, U., Janusaite, M. M., & Vinikovas, A. (2020). Cerebrovascular disease and cognition in chronic kidney disease patients. *Frontiers in Cardiovascular Medicine, 7*, Article 96. https://doi.org/10.3389/fcvm.2020.00096

Patients without peripheral vascular disease (PVD) had significantly better survival than those with PVD regardless of modality ($p<0.001$) (Table 5.7.10). A study revealed that the presence of PVD in CKD patients significantly increases the short-term risk of heart attack and stroke and is a major contributor to mortality[42].

Table 5.7.10: Survival of definitive dialysis by presence of PVD and modality

	No PVD			PVD		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	92.0	91.9	92.0	85.8	82.5	85.2
5-year survival (%)	64.3	47.2	60.5	44.2	22.9	40.1
10-year survival (%)	35.2	23.2	32.6	14.3	4.2	12.4
Median survival (years)	7.1	4.7	6.6	4.3	2.7	3.9

Patients without cancer had significantly better survival than those with cancer regardless of modality ($p<0.001$) (Table 5.7.11). Impaired kidney function may limit the use of nephrotoxic cancer treatments as well as therapies that are cleared by the kidneys and can cause systemic toxicities, thereby contributing to increased mortality risk[43].

Table 5.7.11: Survival of definitive dialysis by presence of cancer and modality

	No cancer			Cancer		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	92.0	92.1	92.0	84.3	90.0	85.0
5-year survival (%)	63.1	46.3	59.5	47.2	38.1	46.2
10-year survival (%)	33.4	22.1	31.0	19.7	11.4	18.8
Median survival (years)	6.9	4.6	6.4	4.7	3.7	4.6

PD, older age (60 years and above), DN, and presence of co-morbidities (IHD, CVD, PVD and cancer) remained as significant risk factors of death in the multivariable analysis (Table 5.7.12). This is reflected in a study where individuals with CKD and multiple comorbidities had a greater risk of mortality compared to those with the same degree of comorbidities but without CKD[44].

Compared to HD patients, the poorer survival among PD patients could be due to several factors, aside from the co-morbidities captured by the registry. For instance, as PD is done at home and self-managed by the patient him/herself or his/her caregiver at own convenience, the efficiency and quality of dialysis may be affected if

[42] Garimella, P. S., & Hirsch, A. T. (2014). Peripheral artery disease and chronic kidney disease: clinical synergy to improve outcomes. *Advances in chronic kidney disease*, *21*(6), 460–471. https://doi.org/10.1053/j.ackd.2014.07.005
[43] Kitchlu, A., Reid, J., Jeyakumar, N., Dixon, S. N., Munoz, A. M., Silver, S. A., & Wald, R. (2022). Cancer risk and mortality in patients with kidney disease: A population-based cohort study. *American Journal of Kidney Diseases, 80*(4), 436-448.e1. https://doi.org/10.1053/j.ajkd.2022.02.020
[44] Fraser, S. D. S., Roderick, P. J., May, C. R., & others. (2015). The burden of comorbidity in people with chronic kidney disease stage 3: A cohort study. *BMC Nephrology, 16*, Article 193. https://doi.org/10.1186/s12882-015-0189-z

it is not done properly and regularly at the recommended frequency. As PD patients also visit their healthcare providers less frequently, infections and other complications may be less recognised, thereby affecting the timeliness of intervention[45]. Findings of poorer outcomes for PD in Asian populations contrasts with most studies based on Western populations, which show no difference by modality, or better short-term survival for PD. This difference has been thought to be possibly a result of the higher prevalence of diabetes in Asian populations (including Singapore), as the glucose load present in PD dialysate is thought to exert a deleterious effect in diabetic patients and make them more prone to infections[46,47].

Table 5.7.12: Adjusted risk of death by factors associated with survival of definitive dialysis

	Hazard ratio	95% confidence interval	P-value
Modality			
HD	1.00	Reference	<0.001**
PD	1.49	1.43-1.56	
Age group			
<60 years	1.00	Reference	<0.001**
⩾60 years	1.89	1.82-1.97	
Sex			
Male	1.00	Reference	0.073
Female	0.97	0.93-1.00	
Ethnicity			
Chinese	1.00	Reference	
Malay	0.91	0.87-0.95	<0.001**
Indian	0.99	0.92-1.05	0.705
Etiology			
Non-DN	1.00	Reference	<0.001**
DN	1.72	1.65-1.79	
IHD			
No	1.00	Reference	<0.001**
Yes	1.46	1.41-1.51	
CVD			
No	1.00	Reference	<0.001**
Yes	1.31	1.26-1.36	
PVD			
No	1.00	Reference	<0.001**
Yes	1.50	1.43-1.57	
Cancer			
No	1.00	Reference	<0.001**
Yes	1.43	1.35-1.52	

[45] Yang F et al. Hemodialysis versus peritoneal dialysis: A comparison of survival outcomes in South-East Asian patients with end-stage renal disease. PLoS ONE. 2015; 10(10): e0140195.
[46] Khoo CY et al. Death and cardiovascular outcomes in end-stage renal failure patients on different modalities of dialysis. Ann Acad Med Singap 2022;51:136-42.
[47] Ng JH, Woo KT and Tan EK. Survival outcome of haemodialysis and peritoneal dialysis. Ann Acad Med Singap 2022;51:132-3

5.8 Management of definitive dialysis

The management of prevalent patients on dialysis was assessed based on several criteria: frequency of dialysis, management of urea, management of anaemia, and management of mineral and bone disease. The criteria of each of these aspects are shown in the table below and they follow as closely to international guidelines[48,49,50,51] as possible.

Criteria	Modality	Indication of adequacy
Frequency of dialysis and management of urea	HD	Thrice weekly dialysis
		Urea reduction ratio (URR) >=65% or fractional clearance of urea (Kt/V) >=1.2%
	PD	Kt/V >=2.0%
Management of anaemia	HD and PD	Haemoglobin (hb) >=10 g/dL with or without erythropoietin stimulating agent (ESA)
Management of mineral and bone disease	HD and PD	Corrected serum calcium (Ca) <2.37 mmol/L
		Serum phosphate (PO_4) >1.13 mmol/L and <1.78 mmol/L
		Serum intact parathyroid hormone (iPTH) >16.3 pmol/L and <33.0 pmol/L

All analyses in this section were stratified by service provider (public sector / VWOs / private sector) and modality (HD / PD) to look out for groups of patients in need of better dialysis management. The most recent reading of each biomarker for each patient in each year were taken and patients without measurement of biomarkers were excluded[52].

About two-thirds of prevalent HD patients were dialysed in centres run by the VWOs, just under one-third in the private sector, and the remaining in the public sector. In 2023, the proportions of prevalent HD patients under the care of the VWOs, private sector and public sector were 65.8%, 32.5% and 1.6% respectively (Table 5.1.2). Compared to the VWOs and private sector in the past decade, the number of HD patients from the public sector was smaller, resulting in less stable trends.

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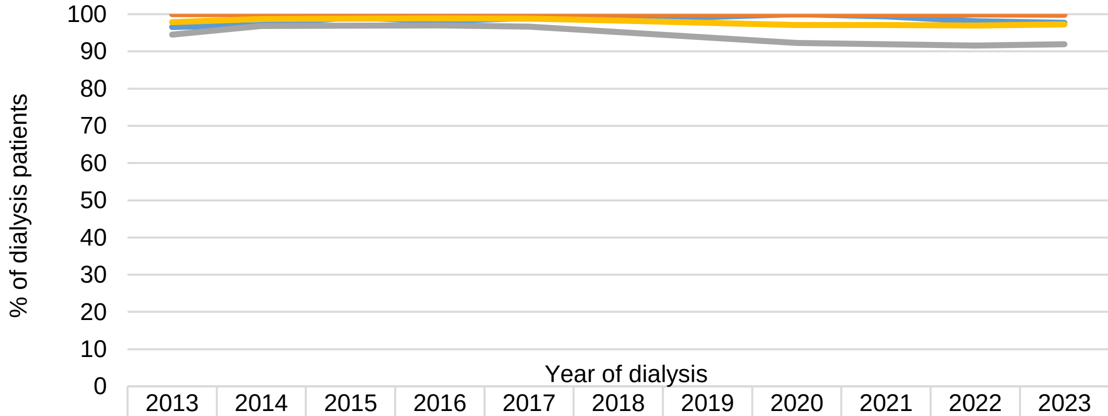
[48] National Kidney Foundation: K/DOQI clinical practice guidelines for hemodialysis adequacy, 2000. American Journal of Kidney Disease. 2001; 37 (suppl 1): S7-S64.
[49] NKF KDOQI Guidelines. National Kidney Foundation, New York. http://kidneyfoundation.cachefly.net/professionals/KDOQI/guideline_upHD_PD_VA/pd_guide2.htm Accessed on 1 Mar 2021.
[50] Mimura I, Tanaka T, Nangaku M. How the target hemoglobin of renal anemia should be? Nephron. 2015; 131: 202-209.
[51] NKF KDOQI Guidelines. National Kidney Foundation, New York. http://kidneyfoundation.cachefly.net/professionals/KDOQI/guidelines_bone/guidestate.htm Accessed on 1 Mar 2021.
[52] The registry captures the absolute value but not the reference range (which differ from each healthcare institution) of each biomarker for each patient.

On the other hand, almost all the prevalent PD patients were cared for by the public sector. In 2023, 98.6% of the PD patients fell under the care of the public sector, with no patients under the care of the VWOs (Table 5.1.2). As there were only a few PD patients from the private sector in the past decade and no PD patient from the VWOs since 2017, their trends were either unstable or not applicable. Hence, statistics related to PD patients from the private sector in the past decade and from the VWOs since 2017 were not shown in the figures though they were included in the overall statistics.

The proportion of prevalent HD patients with thrice weekly dialysis was consistently higher for the public sector and VWOs than the private sector across the years (Figure 5.8.1a). In 2023, 97.7%, 99.8% and 91.9% of the patients from the public sector, VWOs and private sector underwent thrice weekly dialysis respectively.

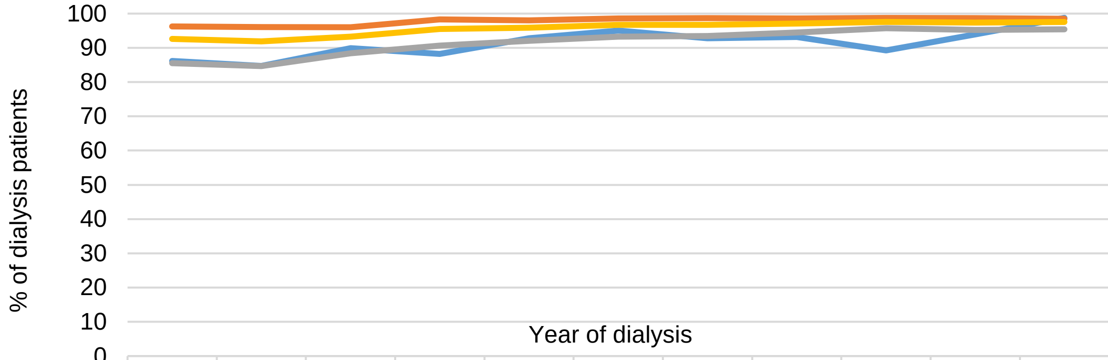
Figure 5.8.1a: Proportion of HD patients with thrice weekly dialysis



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	96.6	97.1	99.1	98.1	99.0	99.0	99.2	100.0	99.4	98.1	97.7
VWO	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0	99.9	99.8
Private	94.5	96.8	96.9	97.0	96.6	95.2	93.7	92.3	91.9	91.6	91.9
Overall	97.8	98.7	98.8	98.9	98.8	98.3	97.7	97.1	97.1	96.9	97.2

The proportion of prevalent HD patients who met the adequate management of urea criteria of URR >=65% or Kt/V >=1.2% was generally higher for the VWOs than the public and private sectors, exceeding 95% every year, and standing at 98.5% in 2023 (Figure 5.8.1b). However, both the public and private sectors were catching up, with the respective proportions rising from 86.2% to 98.8%, and 85.5% to 95.4% from 2013-2023.

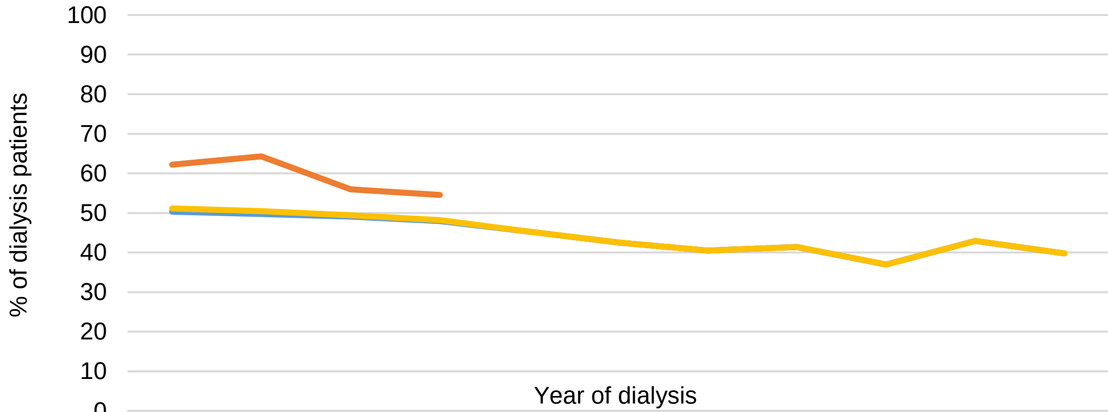
Figure 5.8.1b: Proportion of HD patients with adequate management of urea (URR >=65% or Kt/V >=1.2%)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	86.2	84.7	89.9	88.2	92.8	95.0	92.8	93.2	89.3	93.9	98.8
VWO	96.2	96.0	96.0	98.3	98.0	98.6	98.7	98.6	98.7	98.6	98.5
Private	85.5	84.7	88.4	90.6	92.1	93.3	93.4	94.4	95.7	95.2	95.4
Overall	92.6	91.9	93.3	95.5	95.9	96.7	96.7	97.1	97.6	97.4	97.5

The proportion of prevalent PD patients who met the adequate management of urea criteria of Kt/V >=2.0% dropped from 51.1% in 2013 to 39.8% in 2023 (Figure 5.8.2). Aside from Kt/V, the International Society for Peritoneal Dialysis recommends using other measures to concurrently assess the quality of dialysis, such as anaemia management and bone and mineral management[53].

Figure 5.8.2: Proportion of PD patients with adequate management of urea (Kt/V >=2%)



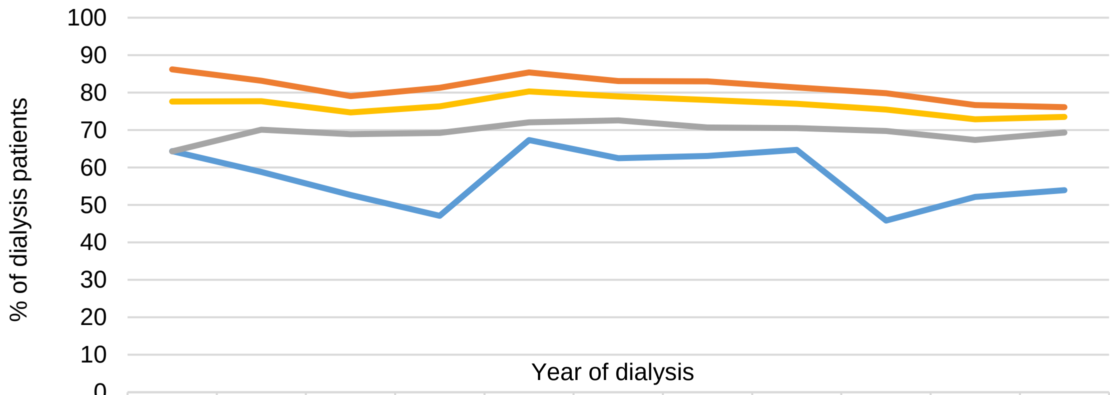
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	50.3	49.7	49.1	47.9	45.2	42.6	40.5	41.4	37.0	43.0	39.8
VWO	62.2	64.3	56.0	54.5							
Overall	51.1	50.5	49.4	48.2	45.2	42.6	40.5	41.4	37.0	43.0	39.8

[53] Brown EA, Blake PG, Boudville N, et al. International Society for Peritoneal Dialysis practice recommendations: prescribing high-quality goal-directed peritoneal dialysis. Journal of the International Society for Peritoneal Dialysis. 2020; 40: 244-253.

The proportion of prevalent HD patients who fulfilled the adequate management of anaemia criteria of hb >=10 g/dL was consistently higher for the VWOs than the public and private sectors across the years (Figure 5.8.3a). In 2023, 53.9%, 76.1% and 69.3% of the patients from the public sector, VWOs and private sector fulfilled the criteria respectively. Overall, about three-quarters of HD patients had adequate management of anaemia.

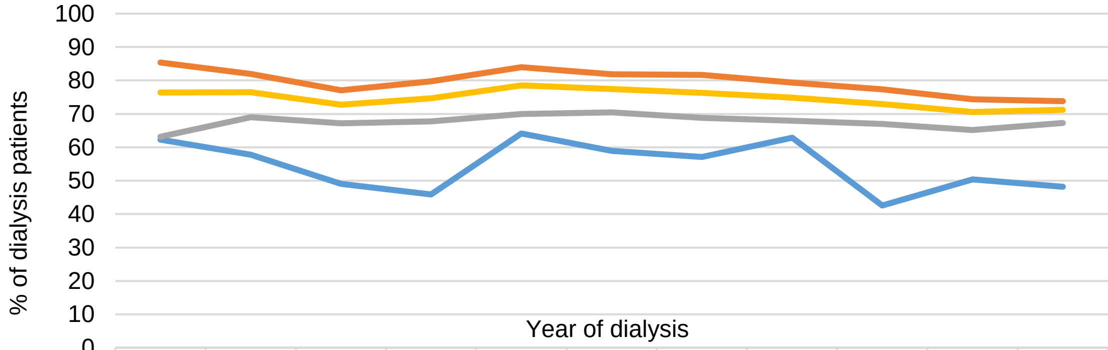
Similar trends were observed after stratification by ESA, a drug that stimulates the production of erythropoietin, a hormone produced primarily by the kidneys and plays a key role in the production of red blood cells (Figures 5.8.3b and 5.8.3c). In addition, regardless of service provider, the proportion of prevalent HD patients not on ESA who had adequate management of anaemia criteria was consistently higher than those on ESA (Figure 5.8.3b, Figure 5.8.3c). This could be due to patients who were prone to anaemia being on ESA.

Figure 5.8.3a: Proportion of HD patients with adequate management of anaemia (hb >=10 g/dL)



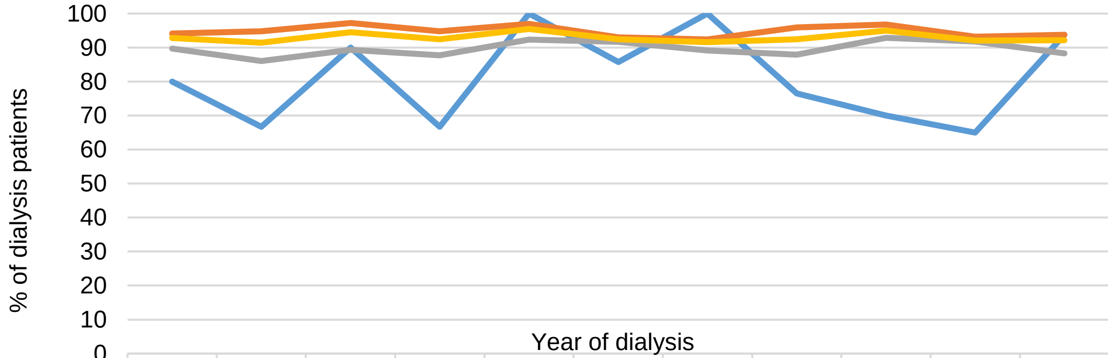
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	64.4	58.8	52.6	47.1	67.3	62.5	63.1	64.8	45.8	52.2	53.9
VWO	86.2	83.1	79.1	81.3	85.4	83.1	83.0	81.3	79.8	76.7	76.1
Private	64.3	70.1	68.9	69.3	72.1	72.6	70.7	70.5	69.8	67.3	69.3
Overall	77.6	77.7	74.7	76.4	80.3	79.0	78.1	77.0	75.5	72.9	73.5

Figure 5.8.3b: Proportion of HD patients on ESA with adequate management of anaemia (hb >=10 g/dL)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	62.3	57.8	49.0	45.9	64.1	58.9	57.1	62.9	42.6	50.3	48.2
VWO	85.4	81.9	77.1	79.7	84.0	81.9	81.7	79.4	77.4	74.4	73.8
Private	63.2	69.0	67.2	67.7	70.0	70.5	68.8	67.9	67.0	65.2	67.3
Overall	76.4	76.5	72.8	74.7	78.5	77.4	76.3	74.9	72.9	70.6	71.3

Figure 5.8.3c: Proportion of HD patients not on ESA with adequate management of anaemia (hb >=10 g/dL)

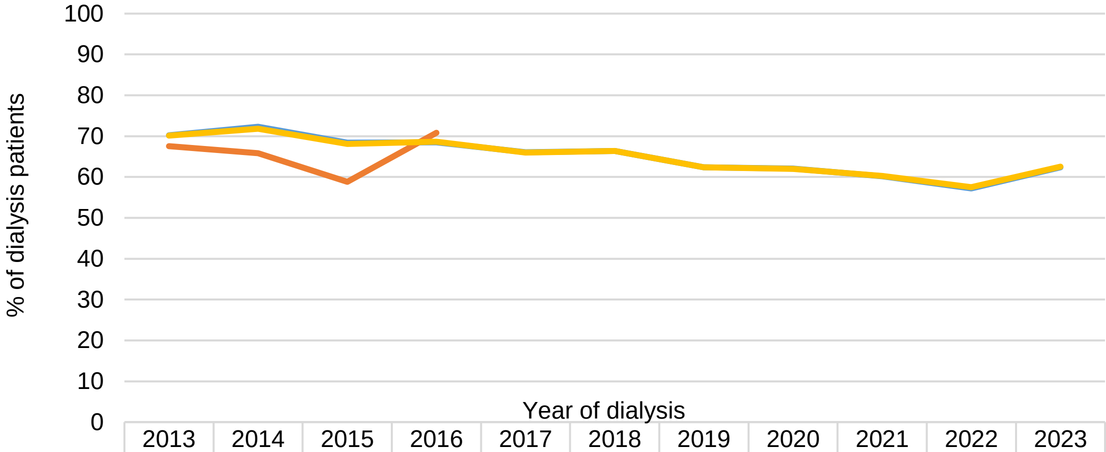


	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	80.0	66.7	90.0	66.7	100.0	85.7	100.0	76.5	70.0	65.0	93.8
VWO	94.2	94.8	97.2	94.8	96.9	93.0	92.4	95.9	96.8	93.2	93.7
Private	89.7	86.1	89.3	87.7	92.3	91.7	89.1	87.9	92.9	91.8	88.3
Overall	92.8	91.4	94.5	92.4	95.5	92.4	91.6	92.4	95.0	92.1	92.2

The proportion of prevalent PD patients who fulfilled the adequate management of anaemia criteria of hb >=10 g/dL dropped from 70.1% in 2013 to 62.5% in 2023 (Figure 5.8.4a).

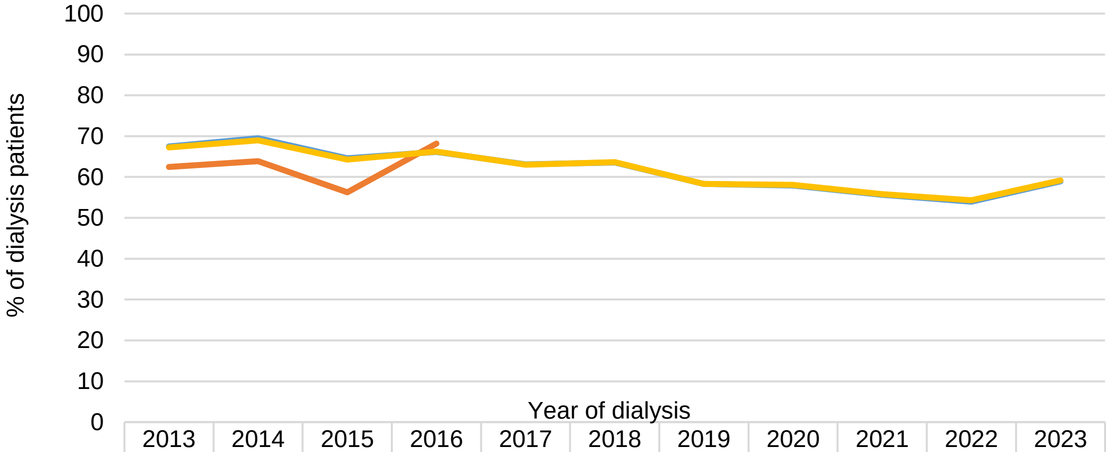
Similar decreasing trend was observed among PD patients taking ESA (Figure 5.8.4b), but the trend since 2017 was stable among those not on ESA (Figure 5.8.4c). Like HD patients, the proportion of PD patients fulfilling the criteria was consistently higher among those who were not taking ESA than those on ESA.

Figure 5.8.4a: Proportion of PD patients with adequate management of anaemia (hb >=10 g/dL)



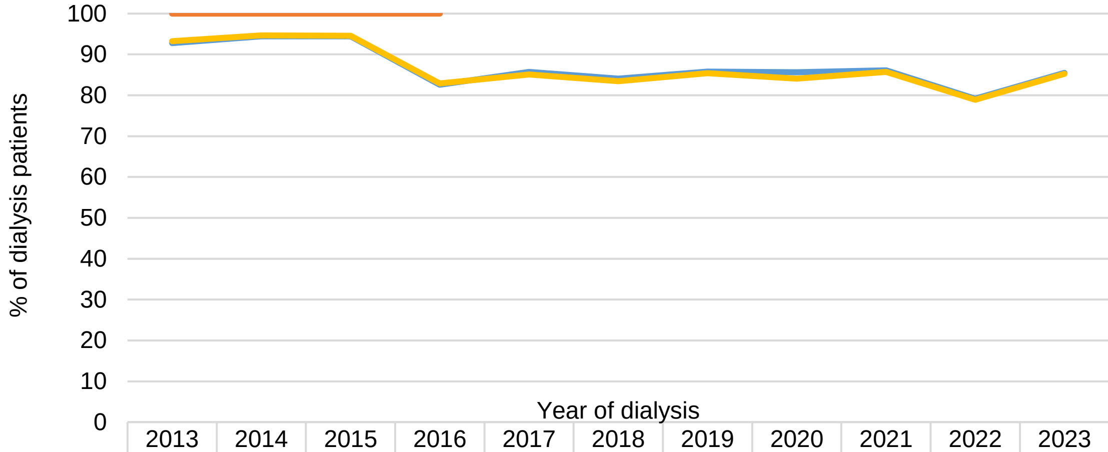
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	70.2	72.3	68.4	68.5	66.1	66.3	62.4	62.0	60.2	57.2	62.3
VWO	67.6	65.8	58.8	70.8							
Overall	70.1	71.8	68.1	68.6	66.0	66.3	62.4	62.0	60.2	57.5	62.5

Figure 5.8.4b: Proportion of PD patients on ESA with adequate management of anaemia (hb >=10 g/dL)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	67.5	69.5	64.6	66.1	63.0	63.5	58.3	58.0	55.7	54.0	59.0
VWO	62.5	63.9	56.3	68.2							
Overall	67.3	69.0	64.3	66.2	63.0	63.6	58.3	58.1	55.8	54.3	59.1

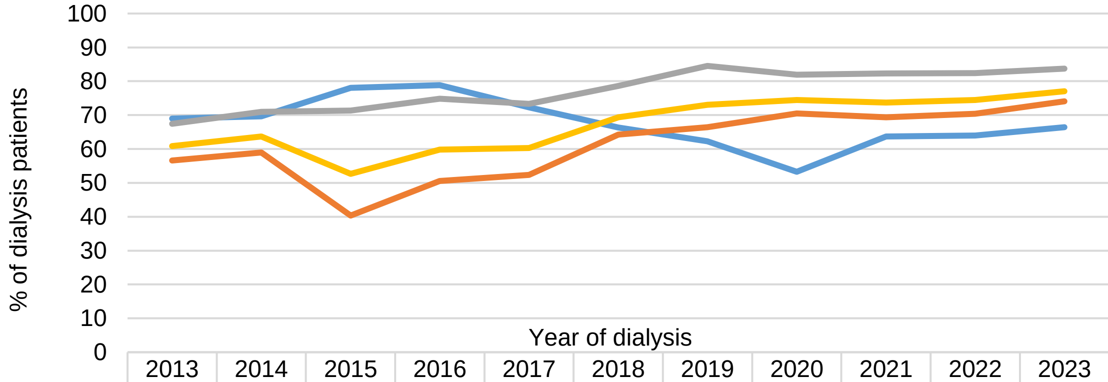
Figure 5.8.4c: Proportion of PD patients not on ESA with adequate management of anaemia (hb >=10 g/dL)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	92.8	94.4	94.4	82.6	85.7	84.1	85.8	85.6	86.1	79.2	85.5
VWO	100.0	100.0	100.0	100.0							
Overall	93.2	94.7	94.6	82.9	85.1	83.4	85.4	84.1	85.7	78.9	85.3

The proportion of prevalent HD patients who passed the adequate management of mineral and bone disease criteria of corrected serum Ca <2.37 mmol/L was generally an inverted U-shape trend for the public sector, a U-shape trend for the VWOs, and an upward trend for the private sector (Figure 5.8.5). In recent years, compared to the public sector and VWOs, more HD patients in the private sector met the guidelines for corrected serum Ca, exceeding 80% every year since 2019. In 2023, 66.4%, 74.1%, and 83.7% of the patients from the public sector, VWOs and private sector met the criteria respectively.

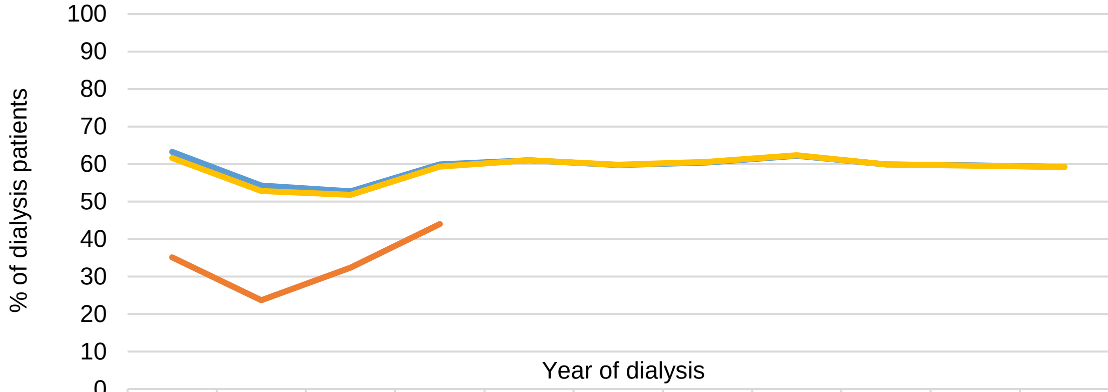
Figure 5.8.5: Proportion of HD patients with adequate management of mineral and bone disease (corrected serum Ca <2.37 mmol/L)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	69.0	69.6	78.1	78.8	72.3	66.3	62.3	53.3	63.7	64.0	66.4
VWO	56.6	59.0	40.3	50.5	52.4	64.3	66.4	70.5	69.3	70.4	74.1
Private	67.4	71.0	71.4	74.8	73.3	78.6	84.5	82.0	82.3	82.4	83.7
Overall	60.9	63.7	52.7	59.8	60.3	69.4	73.0	74.4	73.8	74.5	77.1

The proportion of prevalent PD patients who passed the adequate management of mineral and bone disease criteria of corrected serum Ca <2.37 mmol/L remained similar at 61.7% in 2013 and 59.2% in 2023 (Figure 5.8.6).

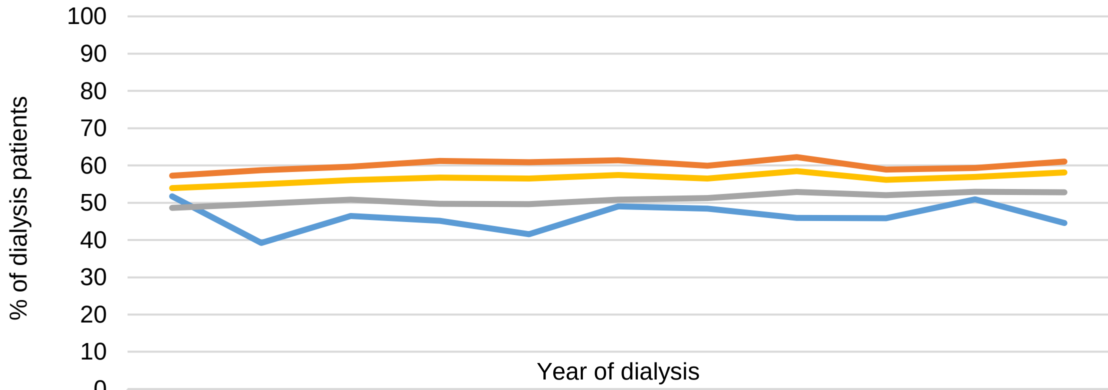
Figure 5.8.6: Proportion of PD patients with adequate management of mineral and bone disease (corrected serum Ca <2.37 mmol/L)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	63.3	54.3	52.7	59.9	61.0	59.8	60.4	62.2	59.9	59.6	59.2
VWO	35.1	23.7	32.3	44.0							
Overall	61.7	52.8	51.8	59.3	61.0	59.8	60.6	62.3	59.9	59.5	59.2

The proportion of prevalent HD patients who had adequate management of mineral and bone disease criteria with serum PO_4 >1.13 mmol/L and <1.78 mmol/L was consistently higher for the VWOs than the public and private sectors across the years (Figure 5.8.7). In 2023, 44.5%, 61.0%, and 52.8% of HD patients from the public sector, VWOs and private sector met the criteria respectively.

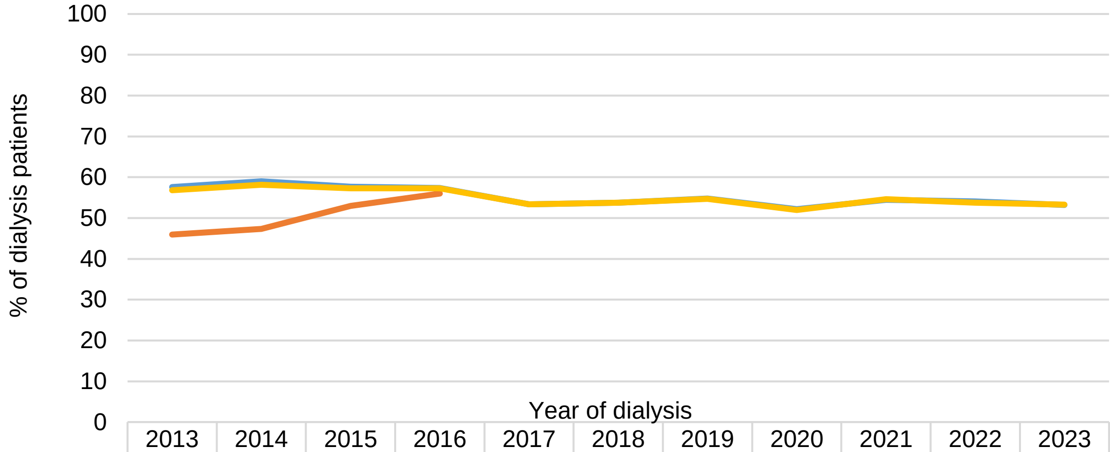
Figure 5.8.7: Proportion of HD patients with adequate management of mineral and bone disease (serum PO_4 >1.13 mmol/L and <1.78 mmol/L)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	51.7	39.2	46.5	45.2	41.6	49.0	48.5	45.9	45.8	50.9	44.5
VWO	57.3	58.7	59.7	61.2	60.9	61.4	59.9	62.2	58.9	59.3	61.0
Private	48.6	49.7	50.8	49.7	49.6	50.8	51.3	52.8	52.0	52.9	52.8
Overall	53.9	54.9	56.1	56.8	56.5	57.4	56.5	58.5	56.2	56.9	58.1

The proportion of prevalent PD patients who passed the adequate management of mineral and bone disease criteria of serum PO_4 >1.13 mmol/L and <1.78 mmol/L remained stable and ranged between 52.0% and 58.2% in 2013 to 2023 (Figure 5.8.8).

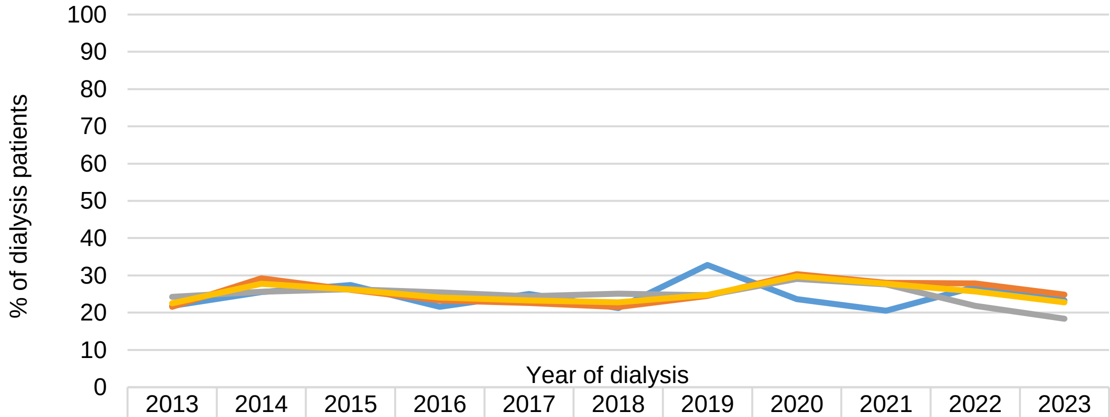
Figure 5.8.8: Proportion of PD patients with adequate management of mineral and bone disease (serum PO_4 >1.13 mmol/L and <1.78 mmol/L)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	57.6	59.0	57.7	57.4	53.4	53.8	54.8	52.2	54.5	54.1	53.2
VWO	46.0	47.4	52.9	56.0							
Overall	56.8	58.2	57.3	57.3	53.3	53.7	54.7	52.0	54.6	53.8	53.3

The proportion of prevalent HD patients who had adequate management of mineral and bone disease with serum iPTH >16.3 pmol/L and <33.0 pmol/L was fairly similar across the three broad service providers for most years (Figure 5.8.9). In 2023, 23.3%, 24.9%, and 18.4% of the patients from the public sector, VWOs and private sector passed the criteria respectively.

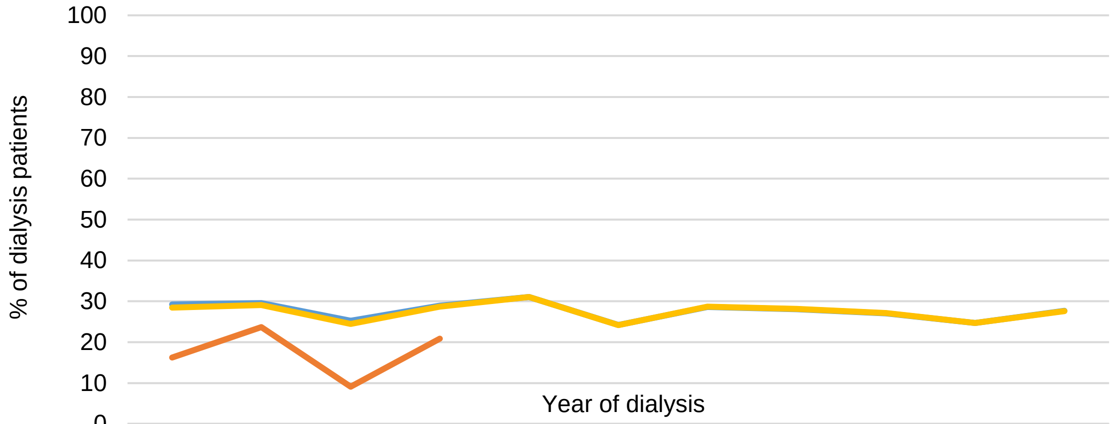
Figure 5.8.9: Proportion of HD patients with adequate management of mineral and bone disease (serum iPTH >16.3 pmol/L and <33.0 pmol/L)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	21.8	25.5	27.4	21.6	25.0	21.2	32.8	23.7	20.5	26.9	23.3
VWO	21.5	29.2	26.1	23.3	22.6	21.5	24.5	30.3	28.0	27.9	24.9
Private	24.3	25.6	26.3	25.5	24.4	25.1	24.6	29.1	27.6	21.8	18.4
Overall	22.5	27.8	26.2	24.0	23.3	22.8	24.7	29.8	27.7	25.7	22.8

The proportion of prevalent PD patients who passed the adequate management of mineral and bone disease criteria of serum iPTH >16.3 pmol/L and <33.0 pmol/L remained stable and ranged between 24.2% and 31.0% from 2013-2023 (Figure 5.8.10).

Figure 5.8.10: Proportion of PD patients with adequate management of mineral and bone disease (serum iPTH >16.3 pmol/L and <33.0 pmol/L)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Public	29.2	29.5	25.3	29.0	31.0	24.2	28.6	28.1	27.1	24.7	27.7
VWO	16.2	23.7	9.1	20.8							
Overall	28.5	29.1	24.4	28.7	31.0	24.2	28.7	28.1	27.1	24.7	27.6

5.9 Incidence of kidney transplant

The incidence rate of kidney transplant in each year was calculated by taking the number of new kidney transplant patients in a year, divided by the number of Singapore residents in the same year. Patients were categorised into 10-year age groups and age standardisation was done using the direct method with the Segi World population as the reference population.

Due to the small number of kidney transplants done each year, the CIR and ASIR of transplant fluctuated year-on-year (Table 5.9.1, Figure 5.9.1). In 2020, the number of kidney transplants hit the lowest point in the past decade, likely due to COVID-19. But numbers increased from 2021, as hospitals resumed transplant services when Singapore moved on to living with COVID-19. In 2023, 99 patients received kidney transplant; the CIR was 23.9 pmp and ASIR was 17.8 pmp. Neither the CIR (p=0.445) nor ASIR of kidney transplant (p=0.356) showed significant changes in incidence over time.

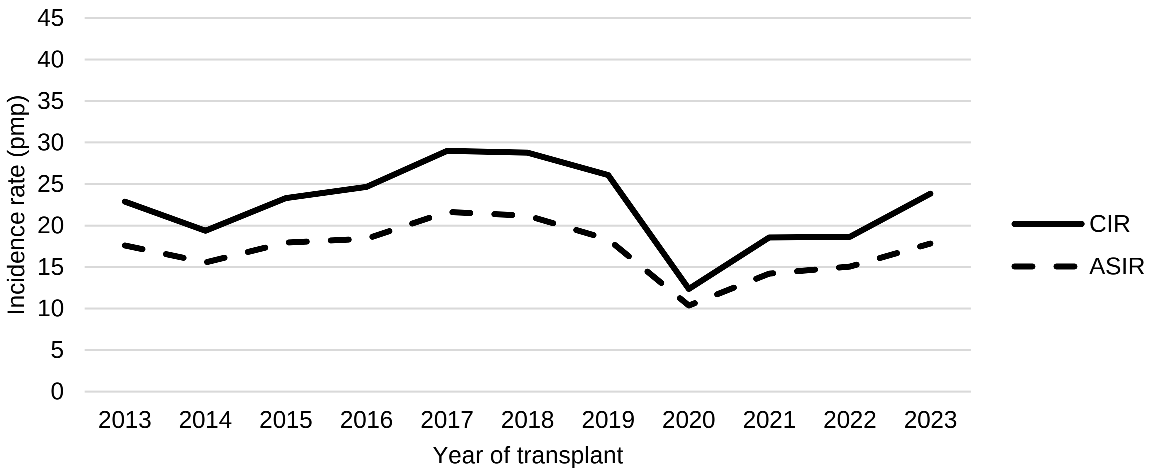
Based on data collected from the USRDS, Asian countries had lower rates of kidney transplant among dialysis patients. In contrast, European countries had the highest rates of kidney transplantation among dialysis patients[54].

Table 5.9.1: Incidence number and rate (pmp) of kidney transplant

Year of transplant	Number	CIR	ASIR
2013	88	22.9	17.6
2014	75	19.4	15.6
2015	91	23.3	18.0
2016	97	24.7	18.4
2017	115	29.0	21.6
2018	115	28.8	21.2
2019	105	26.1	18.3
2020	50	12.4	10.4
2021	74	18.6	14.2
2022	76	18.7	15.1
2023	99	23.9	17.8
P for trend	-	0.445	0.356

[54] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2023/end-stage-renal-disease/11-international-comparisons. Accessed 29 September 2024.

Figure 5.9.1: Incidence rate (pmp) of kidney transplant



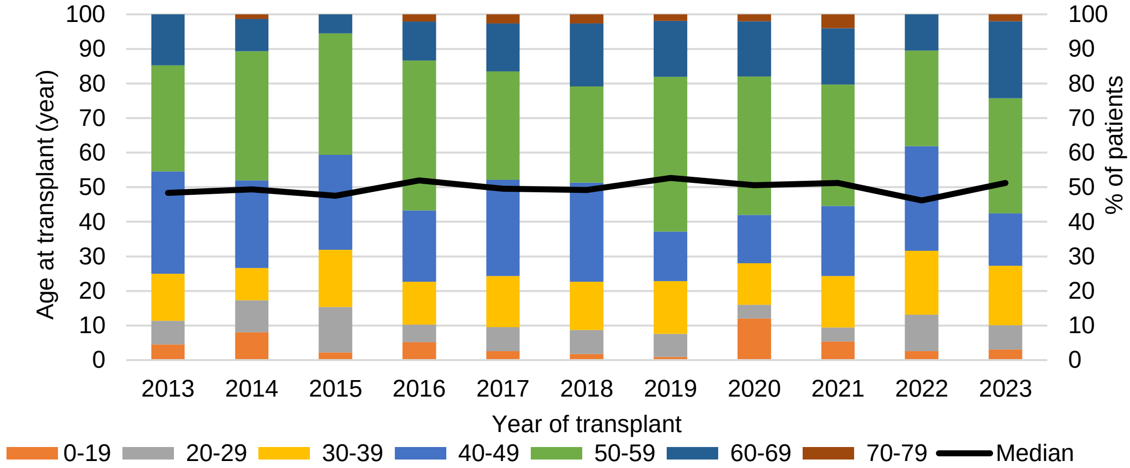
The age-specific incidence rate of kidney transplant fluctuated for all age groups due to the small number of transplants done each year, and there were no significant changes in the age-specific incidence of kidney transplant across all age groups (Table 5.9.2).

Table 5.9.2: Age distribution (%) and age-specific incidence rate (pmp) of kidney transplant

Year of transplant	Age 0-19			Age 20-29			Age 30-39			Age 40-49		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2013	4	4.5	4.6	6	6.8	11.5	12	13.6	19.9	26	29.5	41.3
2014	6	8.0	7.0	7	9.3	13.2	7	9.3	11.8	19	25.3	30.4
2015	2	2.2	2.4	12	13.2	22.4	15	16.5	25.4	25	27.5	40.3
2016	5	5.2	6.0	5	5.2	9.2	12	12.4	20.4	20	20.6	32.5
2017	3	2.6	3.6	8	7.0	14.6	17	14.8	29.3	32	27.8	52.0
2018	2	1.7	2.4	8	7.0	14.6	16	13.9	27.3	33	28.7	54.0
2019	1	1.0	1.2	7	6.7	13.0	16	15.2	26.9	15	14.3	24.5
2020	6	12.0	7.5	2	4.0	3.8	6	12.0	10.0	7	14.0	11.5
2021	4	5.4	5.1	3	4.1	5.8	11	14.9	18.6	15	20.3	25.3
2022	2	2.6	2.5	8	10.5	15.6	14	18.4	23.0	23	30.3	38.1
2023	3	3.0	3.8	7	7.1	13.8	17	17.2	27.3	15	15.2	24.5
P for trend	-	-	0.580	-	-	0.431	-	-	0.652	-	-	0.210
Year of transplant	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2013	27	30.7	45.5	13	14.8	35.3	0	0.0	0.0	0	0.0	0.0
2014	28	37.3	46.4	7	9.3	17.8	1	1.3	5.5	0	0.0	0.0
2015	32	35.2	52.4	5	5.5	11.8	0	0.0	0.0	0	0.0	0.0
2016	42	43.3	68.3	11	11.3	24.5	2	2.1	10.4	0	0.0	0.0
2017	36	31.3	58.6	16	13.9	34.3	3	2.6	14.2	0	0.0	0.0
2018	32	27.8	52.2	21	18.3	43.4	3	2.6	13.1	0	0.0	0.0
2019	47	44.8	77.2	17	16.2	34.0	2	1.9	8.2	0	0.0	0.0
2020	20	40.0	33.2	8	16.0	15.6	1	2.0	3.8	0	0.0	0.0
2021	26	35.1	44.5	12	16.2	23.2	3	4.1	11.0	0	0.0	0.0
2022	21	27.6	35.4	8	10.5	14.9	0	0.0	0.0	0	0.0	0.0
2023	33	33.3	54.7	22	22.2	39.8	2	2.0	6.3	0	0.0	0.0
P for trend	-	-	0.521	-	-	0.843	-	-	0.710	-	-	-

The median age at kidney transplant ranged between 46.2 and 52.7 years in the past decade (p=0.445), and the majority of transplant patients each year were aged between 40-59 years (Figure 5.9.2a).

Figure 5.9.2a: Median age (years) and age distribution (%) of new kidney transplant patients



The age-specific incidence rate of kidney transplants was highest for those aged 50 to 59 years (Figure 5.9.2b, Figure 5.9.3).

Figure 5.9.2b: Age-specific incidence rate (pmp) of kidney transplant across years

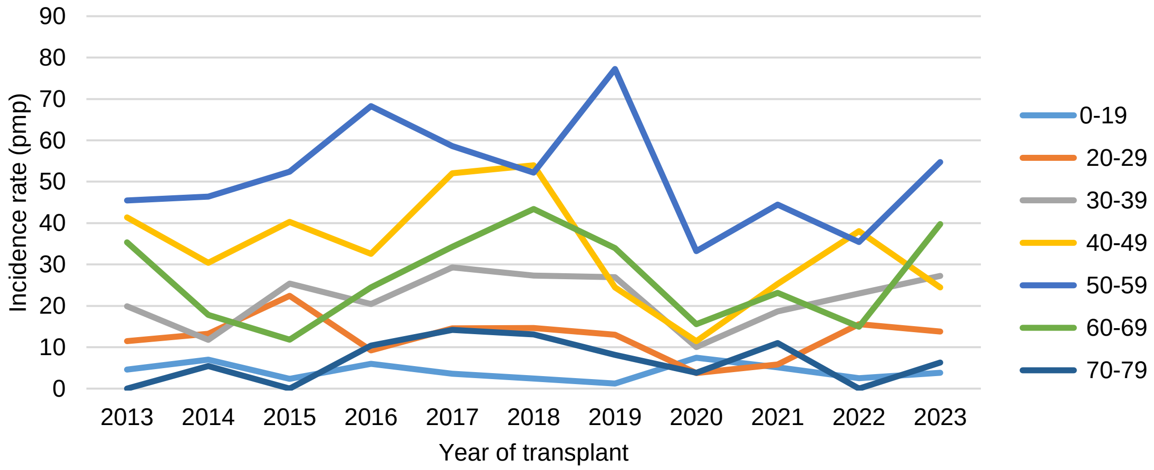
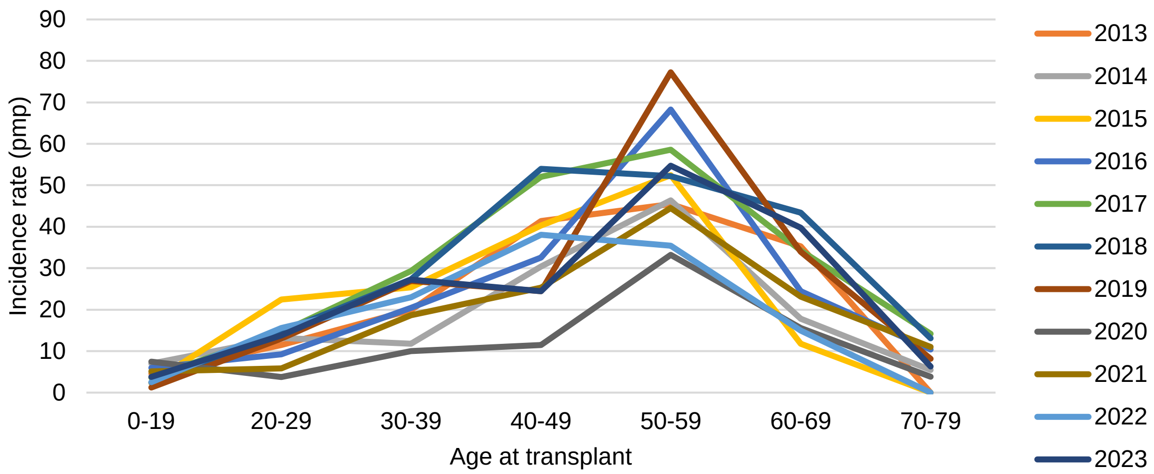


Figure 5.9.3: Age-specific incidence rate (pmp) of kidney transplant across age groups



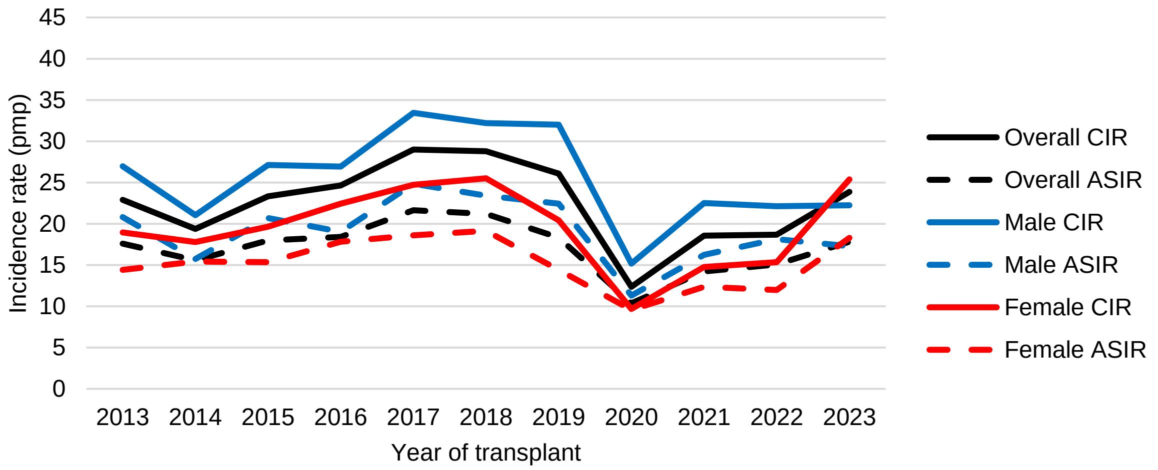
As with the trends of dialysis incidence, males comprised a higher percentage of kidney transplant patients every year up till 2022, and the ASIRs of kidney transplant were generally higher among males than females for most of the years (Table 5.9.3, Figure 5.9.4). In 2023, the ASIR was 17.3 pmp and 18.3 pmp for males and females respectively. The ASIRs for both sexes fluctuated over the years due to the small number of transplants done each year; no significant changes in transplant incidence were observed for either.

Table 5.9.3: Incidence number and rate (pmp) of kidney transplant by sex

Male				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2013	51	58.0	27.0	20.8
2014	40	53.3	21.0	15.7
2015	52	57.1	27.1	20.7
2016	52	53.6	26.9	19.0
2017	65	56.5	33.4	24.8
2018	63	54.8	32.2	23.4
2019	63	60.0	32.0	22.4
2020	30	60.0	15.2	11.3
2021	44	59.5	22.5	16.2
2022	44	57.9	22.1	18.2
2023	45	45.5	22.3	17.3
P for trend	-	-	0.333	0.372

Year of transplant	Female			
	Number	%	CIR	ASIR
2013	37	42.0	18.9	14.4
2014	35	46.7	17.8	15.4
2015	39	42.9	19.6	15.3
2016	45	46.4	22.5	17.8
2017	50	43.5	24.7	18.6
2018	52	45.2	25.5	19.1
2019	42	40.0	20.4	14.4
2020	20	40.0	9.7	9.6
2021	30	40.5	14.8	12.4
2022	32	42.1	15.4	12.0
2023	54	54.5	25.4	18.3
P for trend	-	-	0.577	0.423

Figure 5.9.4: Incidence rate (pmp) of kidney transplant by sex

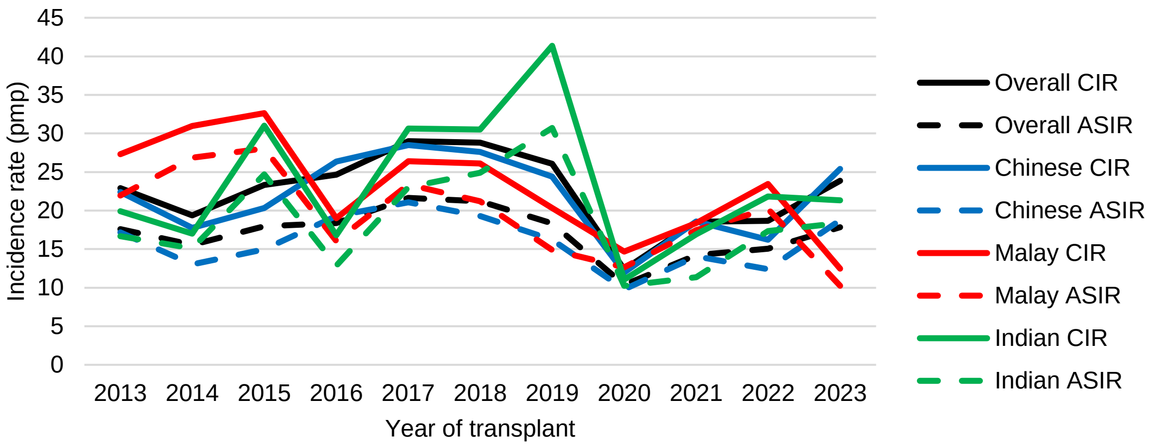


There was no ethnic group with consistently higher or lower incidence rates of kidney transplant across the years (Table 5.9.4, Figure 5.9.5). In 2023, the ASIR was 18.7 pmp, 10.2 pmp and 18.4 pmp for Chinese, Malays and Indians respectively. No significant changes in the ASIR of kidney transplant were observed for the Chinese (p=0.509) and Indians (p=0.711), but it declined among the Malays (p=0.017).

Table 5.9.4: Incidence number and rate (pmp) of kidney transplant by ethnicity

Chinese				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2013	64	72.7	22.4	17.2
2014	51	68.0	17.7	13.0
2015	59	64.8	20.3	15.0
2016	77	79.4	26.3	19.3
2017	84	73.0	28.5	21.1
2018	82	71.3	27.6	19.3
2019	73	69.5	24.4	16.2
2020	36	72.0	12.0	9.8
2021	55	74.3	18.6	14.1
2022	49	64.5	16.2	12.4
2023	78	78.8	25.4	18.7
P for trend	-	-	0.567	0.509
Malay				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2013	14	15.9	27.3	21.9
2014	16	21.3	31.0	26.9
2015	17	18.7	32.6	28.1
2016	10	10.3	19.0	16.0
2017	14	12.2	26.4	23.4
2018	14	12.2	26.1	21.2
2019	11	10.5	20.3	14.9
2020	8	16.0	14.7	12.6
2021	10	13.5	18.4	17.4
2022	13	17.1	23.5	20.2
2023	7	7.1	12.5	10.2
P for trend	-	-	0.009**	0.017*
Indian				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2013	7	8.0	19.9	16.7
2014	6	8.0	17.0	15.1
2015	11	12.1	31.0	24.7
2016	6	6.2	16.8	12.9
2017	11	9.6	30.7	23.0
2018	11	9.6	30.5	24.9
2019	15	14.3	41.4	30.7
2020	4	8.0	11.0	10.2
2021	6	8.1	16.9	11.4
2022	8	10.5	21.8	17.3
2023	8	8.1	21.3	18.4
P for trend	-	-	0.810	0.711

Figure 5.9.5: Incidence rate (pmp) of kidney transplant by ethnicity



Most of the new kidney transplants were done locally, with 88.9% being local transplants in 2023 (Table 5.9.5). The percentage of living donors among local transplants has increased steadily from about 43% in 2017 to 69.4% in 2022, before dipping to 55.7% in 2023. Transplants done overseas were not further stratified by donor status as the registry does not have the data.

Transplants from living donors offer better outcomes[55]. Worldwide, the proportions of transplants coming from living donors in 2021 differ, ranging from about 23% (1 in 4) in the United States to about 80% (4 in 5) in Malaysia. In Taiwan, which has the world's highest incidence and prevalence of CKD5, about 40% (2 in 5) kidney transplants in 2021 were from living donors[56].

Table 5.9.5: Incidence number of kidney transplant by type of donor

Year of transplant	Local transplant						Overseas transplant	
	Living donor		Deceased donor		Total			
	Number	%*	Number	%*	Number	%^	Number	%^
2013	35	50.7	34	49.3	69	78.4	19	21.6
2014	40	70.2	17	29.8	57	76.0	18	24.0
2015	40	55.6	32	44.4	72	79.1	19	20.9
2016	32	44.4	40	55.6	72	74.2	25	25.8
2017	40	43.0	53	57.0	93	80.9	22	19.1
2018	43	53.1	38	46.9	81	70.4	34	29.6
2019	56	62.9	33	37.1	89	84.8	16	15.2
2020	31	67.4	15	32.6	46	92.0	4	8.0
2021	47	66.2	24	33.8	71	95.9	3	4.1
2022	50	69.4	22	30.6	72	94.7	4	5.3
2023	49	55.7	39	44.3	88	88.9	11	11.1

* Among local transplants
^ Among all transplants

[55] Hariharan S, Israni AK, Danovitch G. Long-Term Survival after Kidney Transplantation. N Engl J Med 2021;385:729-43.
[56] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2023/end-stage-renal-disease/11-international-comparisons. Accessed 29 September 2024.

GN was the main cause of CKD5 among new kidney transplant patients (Table 5.9.6). The proportion of new transplant patients with GN was 46.5% in 2023, while the proportion with DN was 22.2%. In contrast to trends for dialysis incidence, where about two-thirds of incident dialysis case were due to DN (Table 5.4.6), there were more patients with GN undergoing transplant than those with DN, as patients with DN tend to have more co-morbidities and higher risk of post-transplant complications[57,58].

Table 5.9.6: Incidence number of kidney transplant by etiology

Year of transplant	DN		GN		Others	
	Number	%	Number	%	Number	%
2013	8	9.1	55	62.5	25	28.4
2014	11	14.7	42	56.0	22	29.3
2015	18	19.8	49	53.8	24	26.4
2016	17	17.5	53	54.6	27	27.8
2017	19	16.5	70	60.9	26	22.6
2018	18	15.7	69	60.0	28	24.3
2019	24	22.9	50	47.6	31	29.5
2020	9	18.0	23	46.0	18	36.0
2021	13	17.6	39	52.7	22	29.7
2022	17	22.4	40	52.6	19	25.0
2023	22	22.2	46	46.5	31	31.3

[57] Chantrel F et al. Abysmal prognosis of patients with type 2 diabetes entering dialysis. Nephrology Dialysis Transplant 1999; 14: 129-136.
[58] Hashmi S et al. Overview of renal transplantation. Minerva Med 2007. 98(6): 713-729.

5.10 Prevalence of kidney transplant

The prevalence rate of kidney transplant in each year was calculated by taking the cumulative number of surviving (existing and new) patients with kidney transplant in a year, divided by the number of Singapore residents in the same year. Patients were categorised into 10-year age groups and age standardisation was done using the direct method with the Segi World population as the reference population.

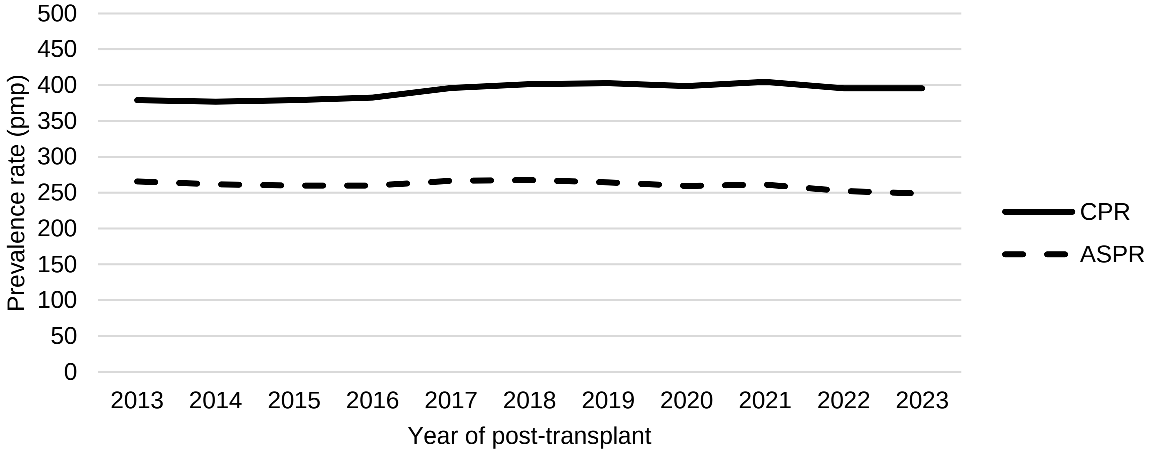
Unlike the incidence trend of kidney transplant which rose and dropped between 2013 and 2023 (Table 5.9.1, Figure 5.9.1), the number of prevalent patients with kidney transplant generally increased since 2013 (Table 5.10.1, Figure 5.10.1). There was a significant rise in CPR from 379.0 pmp in 2013 to 395.5 pmp in 2023 (p=0.004), while the ASPR dropped from 265.8 pmp in 2013 to 248.7 pmp in 2023 (p=0.036). Among countries included in USRDS data, in 2021, the United States had the highest prevalence of kidney transplants, followed by Portugal, both of which had CPRs exceeding 700 pmp (compared to 404 pmp in Singapore)[59].

Table 5.10.1: Prevalence number and rate (pmp) of kidney transplant

Year of post-transplant	Number	CPR	ASPR
2013	1457	379.0	265.8
2014	1459	376.9	261.5
2015	1480	379.2	259.8
2016	1505	382.6	259.9
2017	1570	395.9	266.5
2018	1604	401.6	267.5
2019	1622	402.9	264.3
2020	1612	398.6	259.6
2021	1613	404.6	261.0
2022	1612	395.8	252.2
2023	1641	395.5	248.7
P for trend	-	0.004**	0.036*

[59] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System. https://usrds-adr.niddk.nih.gov/2023/end-stage-renal-disease/11-international-comparisons. Accessed 29 September 2024.

Figure 5.10.1: Prevalence rate (pmp) of kidney transplant



The CPR of kidney transplant increased for those aged 0 to 19 years (p=0.005), 70 to 79 years (p<0.001) and 80 years and above (p<0.001), but it dropped for those aged 20-29 years (p=0.020), 40-49 years (p=0.002) and 50-59 years (p<0.001) (Table 5.10.2).

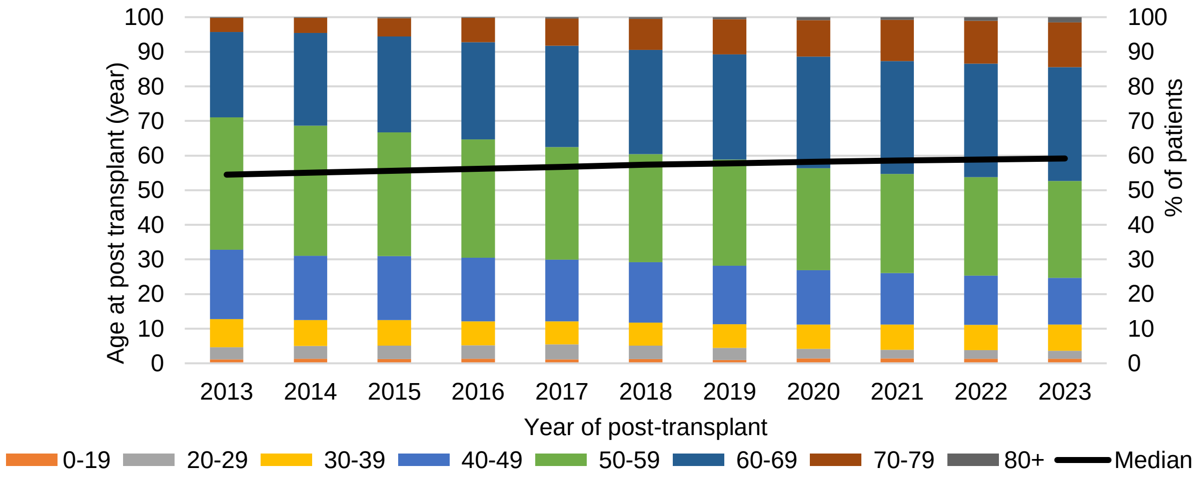
Table 5.10.2: Age distribution (%) and age-specific prevalence rate (pmp) of kidney transplant

Year of post-transplant	Age 0-19			Age 20-29			Age 30-39			Age 40-49		
	Number	%	CPR	Number	%	CPR	Number	%	CPR	Number	%	CPR
2013	17	1.2	19.5	50	3.4	95.7	119	8.2	197.5	292	20.0	464.4
2014	19	1.3	22.2	54	3.7	102.0	109	7.5	183.4	271	18.6	433.9
2015	18	1.2	21.3	57	3.9	106.5	110	7.4	185.9	273	18.4	440.2
2016	20	1.3	23.9	58	3.9	107.2	104	6.9	177.0	277	18.4	450.7
2017	18	1.1	21.8	68	4.3	123.8	104	6.6	179.2	280	17.8	455.3
2018	19	1.2	23.2	63	3.9	115.1	107	6.7	182.9	280	17.5	457.9
2019	16	1.0	19.7	56	3.5	104.2	111	6.8	186.8	275	17.0	449.0
2020	22	1.4	27.4	46	2.9	86.5	112	6.9	187.5	254	15.8	415.7
2021	23	1.4	29.4	40	2.5	77.6	118	7.3	199.9	239	14.8	403.1
2022	21	1.3	26.6	40	2.5	77.9	118	7.3	194.0	229	14.2	379.0
2023	22	1.3	27.8	37	2.3	73.0	125	7.6	200.4	221	13.5	360.7
P for trend	-	-	0.005**	-	-	0.020*	-	-	0.146	-	-	0.002**

Year of post-transplant	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CPR	Number	%	CPR	Number	%	CPR	Number	%	CPR
2013	557	38.2	937.9	359	24.6	975.3	60	4.1	340.7	3	0.2	36.5
2014	548	37.6	907.4	392	26.9	998.2	63	4.3	344.1	3	0.2	34.4
2015	529	35.7	867.0	411	27.8	971.8	77	5.2	418.8	5	0.3	53.5
2016	514	34.2	835.5	423	28.1	940.3	105	7.0	547.6	4	0.3	40.9
2017	511	32.5	831.6	460	29.3	985.8	123	7.8	581.7	6	0.4	59.2
2018	500	31.2	815.2	484	30.2	1000.4	143	8.9	624.8	8	0.5	74.8
2019	496	30.6	815.2	493	30.4	985.8	165	10.2	674.2	10	0.6	86.5
2020	474	29.4	787.5	521	32.3	1013.6	169	10.5	647.5	14	0.9	112.9
2021	463	28.7	792.6	526	32.6	1015.4	191	11.8	701.4	13	0.8	99.0
2022	459	28.5	774.3	528	32.8	985.2	200	12.4	679.4	17	1.1	125.2
2023	459	28.0	761.1	540	32.9	976.8	212	12.9	664.8	25	1.5	178.7
P for trend	-	-	<0.001**	-	-	0.320	-	-	<0.001**	-	-	<0.001**

The median age among prevalent kidney transplant patients increased from 54.5 years in 2013 to 59.2 years in 2023 (<0.001**); the percentage of kidney transplant patients aged 60 years and above also rose from 29.0% in 2013 to 47.3% in 2023 (Figure 5.10.2a).

Figure 5.10.2a: Median age (years) and age distribution (%) of prevalent kidney transplant patients



Every year, the age-specific prevalence rate of kidney transplant was highest for those aged 60 to 69 years (Figure 5.10.2b, Figure 5.10.3).

Figure 5.10.2b: Age-specific prevalence rate (pmp) of kidney transplant across years

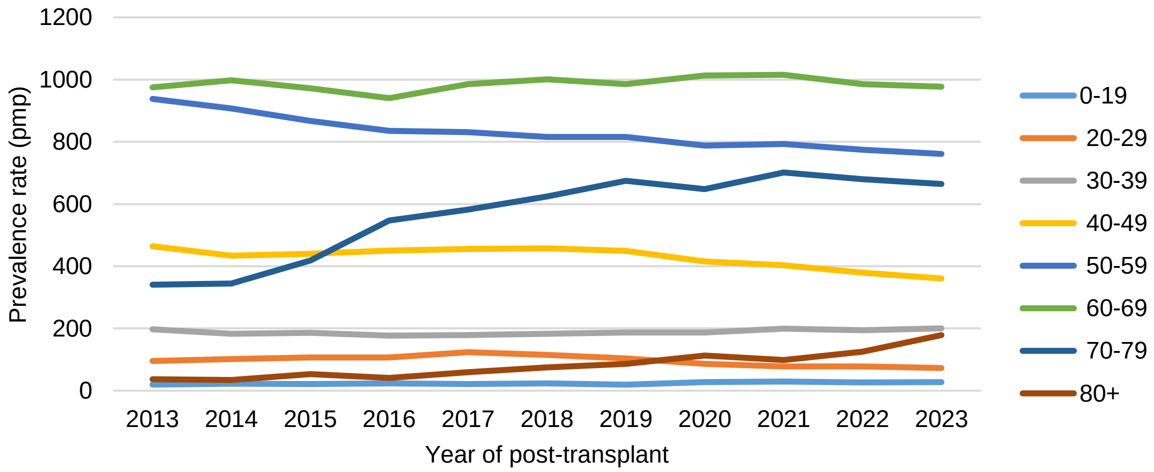
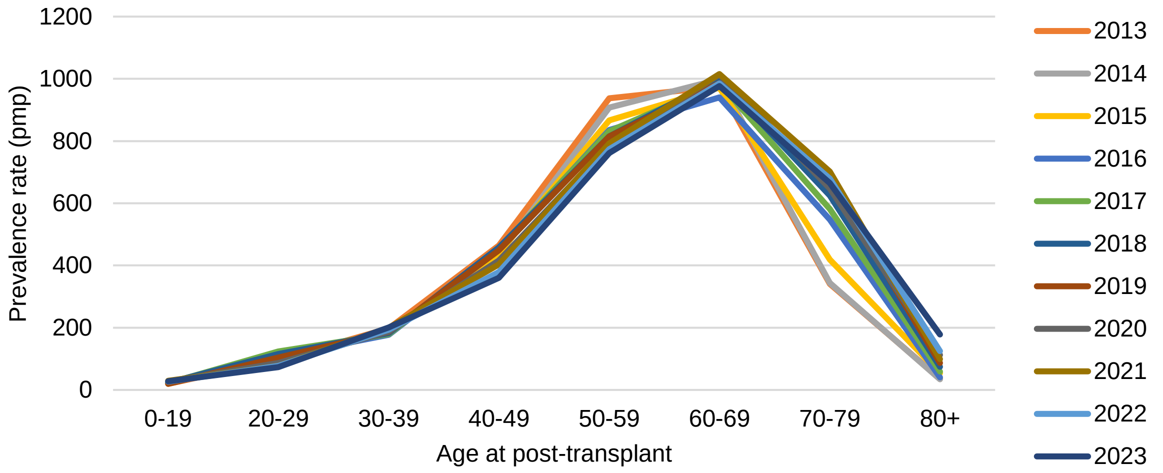


Figure 5.10.3: Age-specific prevalence rate (pmp) of kidney transplant across age groups



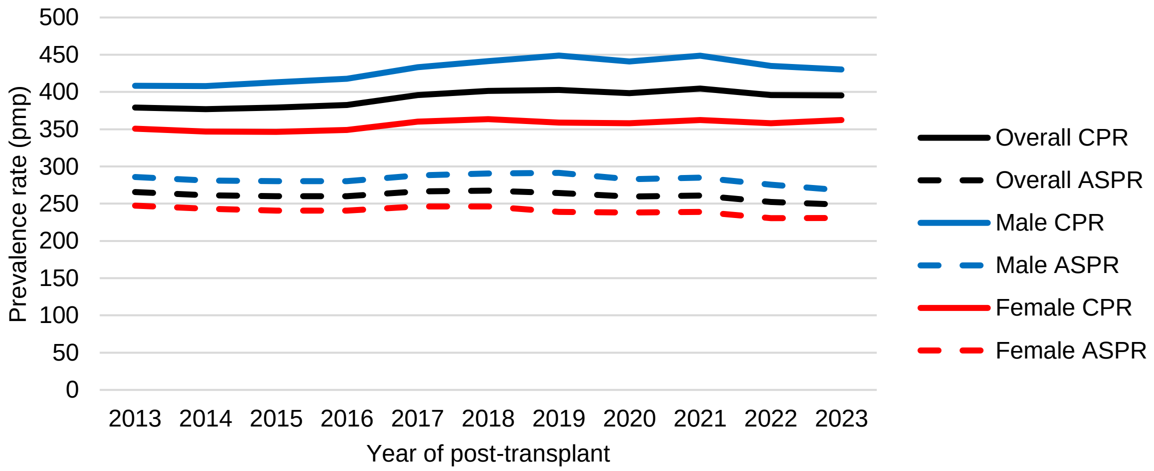
Every year, 53-55% of prevalent kidney transplant patients were males. The ASPRs of kidney transplant were consistently higher among males than females across the years (Table 5.10.3, Figure 5.10.4). In 2023, the ASPR was 268.0 pmp and 231.0 pmp for males and females respectively. The ASPR for males remained stable (p=0.227), while that for females dropped significantly over the years (p=0.003).

Table 5.10.3: Prevalence number and rate (pmp) of kidney transplant by sex

Male				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2013	772	53.0	408.2	285.7
2014	776	53.2	407.9	281.0
2015	792	53.5	413.2	280.3
2016	806	53.6	417.7	280.2
2017	842	53.6	433.2	288.1
2018	863	53.8	441.2	290.5
2019	884	54.5	448.9	291.4
2020	872	54.1	440.9	282.9
2021	876	54.3	448.5	284.9
2022	866	53.7	435.1	275.5
2023	870	53.0	430.3	268.0
P for trend	-	-	0.006**	0.227

Female				
Year of post-transplant	Number	%	CPR	ASPR
2013	685	47.0	350.7	247.4
2014	683	46.8	347.0	243.3
2015	688	46.5	346.4	240.6
2016	699	46.4	348.8	240.8
2017	728	46.4	360.0	246.5
2018	741	46.2	363.5	246.1
2019	738	45.5	358.8	239.2
2020	740	45.9	358.1	238.1
2021	737	45.7	362.4	239.0
2022	746	46.3	358.1	230.6
2023	771	47.0	362.4	231.0
P for trend	-	-	0.005**	0.003**

Figure 5.10.4: Prevalence rate (pmp) of kidney transplant by sex

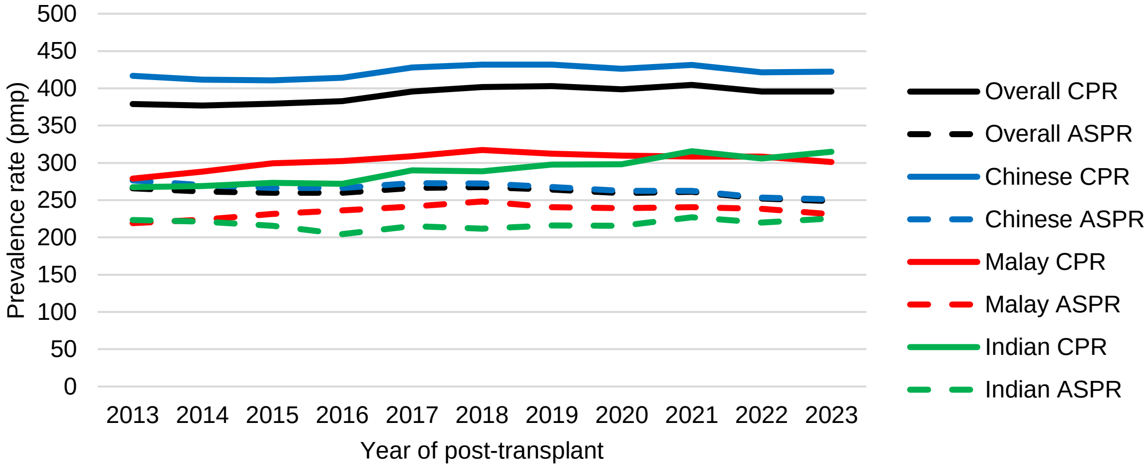


The ASPRs of kidney transplant were consistently higher among Chinese than Malays and Indians across the years (Table 5.10.4, Figure 5.10.5). While the ASPR for Chinese dropped significantly from 276.5 pmp in 2013 to 251.1 pmp in 2023 (p=0.001), no significant changes in the trends of kidney transplant prevalence were observed among the Malays (p=0.082) and Indians (p=0.388).

Table 5.10.4: Prevalence number and rate (pmp) of kidney transplant by ethnicity

Chinese				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2013	1189	81.6	416.6	276.5
2014	1183	81.1	411.6	270.1
2015	1191	80.5	410.7	266.4
2016	1211	80.5	414.3	266.4
2017	1261	80.3	427.7	273.0
2018	1282	79.9	431.8	272.3
2019	1292	79.7	431.6	267.5
2020	1281	79.5	426.0	262.5
2021	1277	79.2	431.4	262.5
2022	1273	79.0	421.7	253.6
2023	1298	79.1	422.5	251.1
P for trend	-	-	0.051	0.001**
Malay				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2013	143	9.8	278.9	219.2
2014	149	10.2	288.4	223.8
2015	156	10.5	299.5	231.4
2016	159	10.6	302.3	236.3
2017	164	10.4	309.0	241.6
2018	170	10.6	317.3	248.2
2019	169	10.4	312.5	240.4
2020	169	10.5	309.8	239.3
2021	168	10.4	308.6	240.5
2022	171	10.6	308.6	238.4
2023	169	10.3	301.1	231.2
P for trend	-	-	0.032*	0.082
Indian				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2013	94	6.5	267.4	223.2
2014	95	6.5	269.1	221.2
2015	97	6.6	273.3	215.7
2016	97	6.4	271.8	204.5
2017	104	6.6	289.8	215.2
2018	104	6.5	288.5	211.9
2019	108	6.7	297.8	216.1
2020	108	6.7	298.1	215.6
2021	112	6.9	315.6	227.0
2022	112	6.9	305.7	219.8
2023	118	7.2	314.8	225.4
P for trend	-	-	<0.001**	0.388

Figure 5.10.5: Prevalence rate (pmp) of kidney transplant by ethnicity



Most of the prevalent kidney transplants were done locally, with 76.3% (about 3 in 4) being local transplants in 2023 (Table 5.10.5). Among the prevalent local transplants, the difference in proportion of transplants between living and deceased donors narrowed over the years, whereby the proportion of transplants from living donors increased and exceeded the proportion from deceased donors in 2021. Transplants done overseas were not further stratified by donor status as the registry does not have the data.

Table 5.10.5: Prevalence number of kidney transplant by type of donor

Year of post-transplant	Local transplant				Overseas transplant	
	Living donor		Deceased donor			
	Number	%	Number	%	Number	%
2013	429	29.4	591	40.6	437	30.0
2014	454	31.1	571	39.1	434	29.8
2015	479	32.4	570	38.5	431	29.1
2016	485	32.2	585	38.9	435	28.9
2017	507	32.3	616	39.2	447	28.5
2018	527	32.9	629	39.2	448	27.9
2019	563	34.7	624	38.5	435	26.8
2020	575	35.7	611	37.9	426	26.4
2021	606	37.6	588	36.5	419	26.0
2022	639	39.6	574	35.6	399	24.8
2023	670	40.8	583	35.5	388	23.6

While at least half of prevalent dialysis patients had DN every year (Table 5.5.6), individuals with DN comprised a minority of prevalent kidney transplant patients (Table 5.10.6). GN was instead more common among prevalent transplant patients, accounting for approximately two-thirds of prevalent transplant patients every year. While the proportion of prevalent transplant patients with DN increased from 8.0% in 2013 to 11.8% in 2023, those with GN dropped from 70.8% in 2013 to 64.1% in 2023.

Table 5.10.6: Prevalence number of kidney transplant by etiology

Year of post-transplant	DN		GN		Others	
	Number	%	Number	%	Number	%
2013	116	8.0	1031	70.8	310	21.3
2014	122	8.4	1021	70.0	316	21.7
2015	134	9.1	1024	69.2	322	21.8
2016	141	9.4	1035	68.8	329	21.9
2017	151	9.6	1074	68.4	345	22.0
2018	155	9.7	1092	68.1	357	22.3
2019	171	10.5	1084	66.8	367	22.6
2020	168	10.4	1073	66.6	371	23.0
2021	173	10.7	1058	65.6	382	23.7
2022	180	11.2	1055	65.4	377	23.4
2023	194	11.8	1052	64.1	395	24.1

5.11 Survival of kidney transplant

Graft survival: the unadjusted survival rate and median survival duration of new kidney transplants were estimated using the Kaplan-Meier method in Tables 5.11.1 to 5.11.10. Event was defined as graft loss (i.e. return to dialysis or kidney transplant waitlist due to non-functioning graft) or all-cause death. Patients were censored if they neither suffered from graft loss nor died by 30 April 2024. Median survival duration is indicated as “not reached (NR)” if more than half of the patients did not suffer from graft loss or were still alive as of 30 April 2024. Grafts that stopped functioning within 30 days were excluded from this section.

Patient survival: the unadjusted survival rate and median survival duration of new kidney transplant patients were estimated using the Kaplan-Meier method in Tables 5.11.1 to 5.11.10. Event was defined as all-cause death. Patients were censored if they were alive as of 30 April 2024. Median survival duration is indicated as “not reached (NR)” if more than half of the patients were alive as of 30 April 2024. Multivariable Cox regression was used to estimate the adjusted risk of death among patients with transplant done locally, accounting for the effects of potential confounders in Table 5.11.11.

The age, sex, ethnicity, etiology and co-morbidities in Tables 5.11.1 to 5.11.11 were based on data captured by the registry around the date of kidney transplant.

Multivariable Cox regression was used to estimate the adjusted risk of death among patients on dialysis and those with transplant done locally, accounting for the effects of potential confounders in Table 5.11.12. For patients who underwent dialysis prior to transplant, their survival time were counted twice: (1) as dialysis patients where their survival time = time from start of definitive dialysis to transplant, they were censored at the date of transplant, and the potential confounders were based on data captured by the registry at the start of definitive dialysis; (2) as transplant patients where their survival time = time from date of transplant to death or 30 April 2024 (whichever earlier), and the potential confounders were based on data captured by the registry around the date of transplant.

1-, 5- and 10-year graft survival were high at 97.7%, 89.7% and 76.3% respectively (Table 5.11.1). 1-, 5- and 10-year patient survival were also high at 98.5%, 93.6% and 85.0% respectively and outperformed patients on dialysis (90.9%, 57.0% and 29.3% at 1-, 5- and 10-year from the start of definitive dialysis; Table 5.7.2).

Table 5.11.1: Graft and patient survival of kidney transplant

	Graft	Patient
1-year survival (%)	97.7	98.5
5-year survival (%)	89.7	93.6
10-year survival (%)	76.3	85.0
Median survival (years)	19.6	NR

Among patients with transplants done locally, those who received kidneys from living donors had significantly better graft (p<0.001) and patient (p<0.001) survival than those who received a kidney from deceased donors (Table 5.11.2), a pattern that is generally observed globally. For instance, in the United States, for transplants performed between 2002 to 2018, allografts from living donors had better survival rates of 99%, 94%, and 84% respectively, while allograft survival from deceased donors were 97%, 90%, and 77% at 1, 5, and 10 years[60]. As of 2019, 1- and 5-year year graft survival in Australia were 98% and 91% for living donors, and 96% and 83% for deceased donors; patient survival was 100% and 96% for living donor transplants, and 98% and 89% at 1 and 5 years respectively for transplants from deceased donors[61].

Table 5.11.2: Graft and patient survival of kidney transplant by type of donor

	Living		Deceased	
	Graft	Patient	Graft	Patient
1-year survival (%)	99.2	99.3	96.4	97.8
5-year survival (%)	93.9	96.1	86.2	91.2
10-year survival (%)	82.9	89.6	68.8	81.1
Median survival (years)	20.8	NR	15.9	22.6

Younger patients aged below 60 years had significantly better graft (p<0.001) and patient (p<0.001) survival than older patients aged 60 years and above (Table 5.11.3).

Table 5.11.3: Graft and patient survival of kidney transplant by age group

	Age <60 years		Age ⩾60 years	
	Graft	Patient	Graft	Patient
1-year survival (%)	98.0	98.7	95.5	96.3
5-year survival (%)	90.4	94.5	83.7	85.5
10-year survival (%)	77.5	87.0	64.5	65.8
Median survival (years)	20.0	NR	14.8	14.8

Female patients had significantly better graft (p=0.009) and patient (p=0.021) survival compared to males (Table 5.11.4).

Table 5.11.4: Graft and patient survival of kidney transplant by sex

	Male		Female	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.5	98.4	97.9	98.5
5-year survival (%)	89.2	93.8	90.3	93.4
10-year survival (%)	74.9	84.7	78.0	85.5
Median survival (years)	18.3	23.5	21.7	NR

[60] Wang JH and Hart A. Global Perspective on Kidney Transplantation: United States. KIDNEY360 2; 2021. 1836–1839.
[61] Wyld M, Wyburn K, Chadban S. Global Perspective on Kidney Transplantation: United States. KIDNEY360 2: 1641–1644, 2021.

Chinese had significantly better graft survival than Malays (p<0.001) and Indians (p<0.001) (Table 5.11.5). However, there were no significant differences in patient survival across the three ethnic groups.

Table 5.11.5: Graft and patient survival of kidney transplant by ethnicity

	Chinese		Malay		Indian	
	Graft	Patient	Graft	Patient	Graft	Patient
1-year survival (%)	97.8	98.6	96.6	97.3	98.3	98.9
5-year survival (%)	90.9	94.1	85.9	92.5	83.9	90.8
10-year survival (%)	78.2	85.3	69.3	86.1	65.6	80.8
Median survival (years)	20.4	NR	15.7	22.1	12.9	NR

Patients without DN had significantly better graft (p<0.001) and patient (p<0.001) survival than those with DN (Table 5.11.6). While studies have found that the projected survival gain from transplant among diabetic CKD patients can outstrip than that in non-diabetic patients, their long-term survival post-transplant nevertheless remains inferior to that of non-diabetic transplant recipients[62]. This is consistent with data from the SRR.

Table 5.11.6: Graft and patient survival of kidney transplant by etiology

	Non-DN		DN	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.8	98.6	96.8	97.8
5-year survival (%)	90.6	94.5	84.2	87.8
10-year survival (%)	77.6	86.7	67.0	73.5
Median survival (years)	20.8	NR	12.8	15.3

Patients without IHD had significantly better graft (p<0.001) and patient (p<0.001) survival than those with IHD (Table 5.11.7).

Table 5.11.7: Graft and patient survival of kidney transplant by presence of IHD

	No IHD		IHD	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.7	98.6	98.1	98.3
5-year survival (%)	90.5	94.7	86.9	89.1
10-year survival (%)	77.7	87.0	69.7	75.9
Median survival (years)	20.4	NR	14.9	16.8

Graft survival was not significantly different between patients without CVD and those with CVD (p=0.200), but patient survival was comparatively better among kidney transplant patients without CVD (p=0.005) (Table 5.11.8).

[62] Phillips J, Chen J, Ooi E, Prunster J and Lim WH. Global Epidemiology, Health Outcomes, and Treatment Options for Patients With Type 2 Diabetes and Kidney Failure. Frontiers in Clinical Diabetes and Healthcare 2021; 2.

Table 5.11.8: Graft and patient survival of kidney transplant by presence of CVD

	No CVD		CVD	
	Graft	Patient	Graft	Patient
1-year survival (%)	98.1	98.7	90.8	94.9
5-year survival (%)	90.0	93.9	87.4	91.4
10-year survival (%)	76.4	85.4	77.1	79.5
Median survival (years)	19.7	NR	15.0	17.4

Graft survival did not differ significantly between patients with and without PVD (p=0.185); however, patients without PVD had significantly better patient (p=0.003) survival than those with PVD (Table 5.11.9).

Table 5.11.9: Graft and patient survival of kidney transplant by presence of PVD

	No PVD		PVD	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.8	98.6	95.3	97.7
5-year survival (%)	90.0	93.9	86.8	89.2
10-year survival (%)	76.5	85.5	77.4	73.7
Median survival (years)	19.7	NR	12.9	NR

There were no significant differences in graft (p=0.909) and patient (p=0.362) survival among those with cancer compared to those without cancer (Table 5.11.10).

Table 5.11.10: Graft and patient survival of kidney transplant by presence of cancer

	No cancer		Cancer	
	Graft	Patient	Graft	Patient
1-year survival (%)	98.0	98.8	97.0	97.0
5-year survival (%)	90.6	94.4	83.1	88.2
10-year survival (%)	77.1	86.0	69.7	74.3
Median survival (years)	19.6	NR	NR	NR

Among patients with transplants done locally, transplant from deceased donor (p<0.001), older age (60 years and above) (p<0.001), presence of DN and IHD (p<0.001, p=0.002 respectively) remained as significant risk factors of death in the multivariable analysis (Table 5.11.11).

Table 5.11.11: Adjusted risk of death by factors associated with patient survival among kidney transplant patients

	Hazard ratio	95% confidence interval	P-value
Transplant from			
Living donor	1.00	Reference	<0.001**
Deceased donor	2.54	1.96-3.31	
Age group			
<60 years	1.00	Reference	<0.001**
⩾60 years	3.36	2.26-4.99	
Sex			
Male	1.00	Reference	0.325
Female	0.89	0.71-1.12	
Ethnicity			
Chinese	1.00	Reference	
Malay	1.16	0.86-1.56	0.339
Indian	1.38	0.93-2.04	0.105
Etiology			
Non-DN	1.00	Reference	<0.001**
DN	2.62	1.78-3.85	
IHD			
No	1.00	Reference	0.002**
Yes	1.61	1.19-2.18	
CVD			
No	1.00	Reference	0.332
Yes	1.35	0.74-2.46	
PVD			
No	1.00	Reference	0.336
Yes	1.42	0.70-2.87	
Cancer			
No	1.00	Reference	0.954
Yes	1.02	0.48-2.18	

Aside from transplant patients, Table 5.11.12 also included dialysis patients without transplant. Patients with kidney transplant, regardless of donor type, had significantly lower risk of death than dialysis patients without transplant. Older age (60 years and above), DN, and presence of co-morbidities (IHD, CVD, PVD and cancer) were also significant risk factors of death among dialysis and transplant patients.

Table 5.11.12: Adjusted risk of death by factors associated with patient survival among definitive dialysis and kidney transplant patients

	Hazard ratio	95% confidence interval	P-value
Renal replacement therapy			
Dialysis	1.00	Reference	
Transplant from living donor	0.20	0.16-0.24	<0.001**
Transplant from deceased donor	0.45	0.39-0.51	<0.001**
Age group			
<60 years	1.00	Reference	<0.001**
⩾60 years	1.86	1.79-1.93	
Sex			
Male	1.00	Reference	0.221
Female	0.98	0.95-1.01	
Ethnicity			
Chinese	1.00	Reference	
Malay	0.89	0.85-0.93	<0.001**
Indian	0.98	0.92-1.05	0.605
Etiology			
Non-DN	1.00	Reference	<0.001**
DN	1.68	1.61-1.75	
IHD			
No	1.00	Reference	<0.001**
Yes	1.45	1.40-1.51	
CVD			
No	1.00	Reference	<0.001**
Yes	1.31	1.26-1.37	
PVD			
No	1.00	Reference	<0.001**
Yes	1.48	1.41-1.55	
Cancer			
No	1.00	Reference	<0.001**
Yes	1.37	1.29-1.45	

6. CONCLUSION

Although survival among dialysis patients has improved over the years, on top of the direct costs from medical expenses, lifestyle changes are also required to accommodate the treatment. Studies have indicated that kidney transplant is a good alternative treatment to dialysis as transplant patients have better survival and quality of life with fewer disruptions to their daily living, compared to dialysis patients who must set aside several hours for each dialysis session[63,64]. However, the incidence rate of CKD5 is rising faster than the incidence rate of transplant. Moreover, the incidence rate of CKD5 is expected to further accelerate in future with an ageing population and concomitant increase in chronic disease prevalence in Singapore. It is therefore important for individuals who have not been diagnosed with CKD to take preventive action.

CKD can be prevented by leading a healthy lifestyle, such as having a balanced diet and opting for healthier food options, exercising and maintaining a healthy weight, not smoking and going for regular screening for diabetes, hypertension, and hyperlipidaemia. As diabetes and hypertension are common chronic diseases that increase the risk of CKD, individuals with these conditions should seek regular review with their family doctor for timely intervention. For individuals who have been diagnosed with CKD in the early stages, progression to late stages can be controlled with appropriate medication and healthy lifestyle behaviours.

[63] Tonelli M. et al. Systematic Review: Kidney Transplantation Compared With Dialysis in Clinically Relevant Outcomes. American Journal of Transplantation 2011; 11: 2093–2109.
[64] Iqbal M. et al. Quality of Life Is Improved in Renal Transplant Recipients Versus That Shown in Patients With Chronic Kidney Disease With or Without Dialysis. Experimental and Clinical Transplantation 2020; Suppl 1: 64-67.

Annex

Prevalent patients by service providers as of 31 December 2023

Public hospitals and affiliated dialysis centres	HD	PD	Transplant
SINGAPORE GENERAL HOSPITAL	10	472	822
TAN TOCK SENG RENAL CENTRE	11	153	37
CHANGI GENERAL HOSPITAL	6	111	0
KHOO TECK PUAT HOSPITAL	2	130	0
NG TENG FONG GENERAL HOSPITAL	7	66	1
SENGKANG GENERAL HOSPITAL	7	71	0
NATIONAL UNIVERSITY HOSPITAL	3	173	588
NUH DIALYSIS CENTRE	59	0	0
NUH RENAL CENTRE	20	0	0
SHAW NKF - NUH CHILDREN'S KIDNEY CENTRE	3	15	42
Subtotal	**128**	**1191**	**1490**
Voluntary Welfare Organisations	**HD**	**PD**	**Transplant**
ANG MO KIO THYE HUA KWAN HOSPITAL DIALYSIS CENTRE	85	0	0
FOO HAI - NKF DIALYSIS CENTRE	74	0	0
HONG LEONG - NKF DIALYSIS CENTRE (ALJUNIED CRESCENT)	0	0	0
IFPAS - NKF DIALYSIS CENTRE (SERANGOON)	107	0	0
IHSAN KIDNEY CARE (IKC)	56	0	0
JO & GERRY ESSERY NKF DIALYSIS CENTRE (BLK 204 MARSILING)	127	0	0
KWAN IM THONG HOOD CHO TEMPLE - NKF DIALYSIS CENTRE (KOLAM AYER)	146	0	0
KWAN IM THONG HOOD CHO TEMPLE - NKF DIALYSIS CENTRE (SIMEI)	0	0	0
LE CHAMP - NKF DIALYSIS CENTRE (BLK 639 YISHUN ST 61)	114	0	0
LEONG HWA CHAN SI TEMPLE - NKF DIALYSIS CENTRE (TECK WHYE)	106	0	0
NEW CREATION CHURCH - NKF DIALYSIS CENTRE	92	0	0
NKF BUKIT PANJANG DIALYSIS CENTRE	93	0	0
NKF DIALYSIS CENTRE (BLK 365 WOODLANDS II)	112	0	0
NKF DIALYSIS CENTRE SUPPORTED BY KEPPEL	117	0	0
NKF DIALYSIS CENTRE SUPPORTED BY MAN FATT LAM BUDDHIST TEMPLE (105 BEDOK NORTH)	92	0	0
NKF DIALYSIS CENTRE SUPPORTED BY NGIAM KIA HUM & FAMILY	204	0	0
NKF DIALYSIS CENTRE SUPPORTED BY TL WHANG FOUNDATION (BLK 427 PASIR RIS)	126	0	0
NKF HOUGANG PUNGGOL DIALYSIS CENTRE	119	0	0
NKF INTEGRATED RENAL CENTRE (CP1)	219	0	0

NKF INTEGRATED RENAL CENTRE (CP2)	107	0	0
NKF JURONG EAST DIALYSIS CENTRE SUPPORTED BY YUHUA GRASSROOTS ORGANISATIONS	124	0	0
NTUC INCOME - NKF DIALYSIS CENTRE (BUKIT BATOK)	87	0	0
NTUC/SINGAPORE POOLS - NKF DIALYSIS CENTRE (TAMPINES)	140	0	0
PEI HWA FOUNDATION - NKF DIALYSIS CENTRE (ANG MO KIO)	123	0	0
QUEENSTOWN - NKF DIALYSIS CENTRE	149	0	0
SAF - NKF DIALYSIS CENTRE (CLEMENTI)	151	0	0
SAKYADHITA -NKF DIALYSIS CENTRE (UPPER BOON KENG)	103	0	0
SCAL - NKF DIALYSIS CENTRE (YISHUN)	76	0	0
SECK HONG CHOON - NKF DIALYSIS CENTRE	110	0	0
SHENG HONG TEMPLE - NKF DIALYSIS CENTRE (JURONG WEST)	114	0	0
SIA - NKF DIALYSIS CENTRE (TOA PAYOH)	148	0	0
SINGAPORE BUDDHIST WELFARE SERVICES - NKF DIALYSIS CENTRE (HOUGANG)	193	0	0
SINGAPORE POOLS - NKF DIALYSIS CENTRE (BEDOK)	143	0	0
TAMPINES CHINESE TEMPLE - NKF DIALYSIS CENTRE (PASIR RIS)	110	0	0
TAY CHOON HYE - NKF DIALYSIS CENTRE (KIM KEAT)	100	0	0
THE HOUR GLASS - NKF DIALYSIS CENTRE (WEST COAST)	87	0	0
THE HOUR GLASS NKF DIALYSIS CENTRE (ADMIRALTY BRANCH)	105	0	0
THE SINGAPORE BUDDHIST LODGE - NKF DIALYSIS CENTRE (128 BUKIT MERAH VIEW)	98	0	0
THE SIRIVADHANABHAKDI FOUNDATION NKF DIALYSIS CENTRE (JW2)	117	0	0
THONG TECK SIAN TONG LIAN SIN SIA - NKF DIALYSIS CENTRE (WOODLANDS)	116	0	0
TOA PAYOH SEU TECK SEAN TONG - NKF DIALYSIS CENTRE (YISHUN)	75	0	0
WESTERN DIGITAL - NKF DIALYSIS CENTRE (ANG MO KIO)	160	0	0
WOH HUP - NKF DIALYSIS CENTRE (GHIM MOH)	118	0	0
WONG SUI HA EDNA - NKF DIALYSIS CENTRE	129	0	0
KDF - BISHAN CENTRE	99	0	0
KDF - GHIM MOH CENTRE (HD)	87	0	0
KDF - KRETA AYER (HD)	78	0	0
KDF - SAN WANG WU TI CENTRE @ ADMIRALTY LINK	24	0	0
Subtotal	**5260**	**0**	**0**
Private clinics and dialysis centres	**HD**	**PD**	**Transplant**
ACE DIALYSIS PTE LTD	32	0	0
ACER DIALYSIS PTE LTD	32	0	0
AEGIS DIALYSIS CENTRE	31	0	0

ASIA KIDNEY DIALYSIS CENTRE (BEDOK)	55	0	0
ASIA KIDNEY DIALYSIS CENTRE (JURONG)	35	0	0
ASIA KIDNEY DIALYSIS CENTRE (TAMPINES) BLK 139	91	0	0
ASIA KIDNEY DIALYSIS CENTRE (TECK WHYE)	33	0	0
ASIA KIDNEY DIALYSIS CENTRE (TP) BLK-484	0	0	0
ASIA KIDNEY DIALYSIS CENTRE (TPY)	0	0	0
COMPLEX MEDICAL CENTRE (CHANGI)	7	0	0
DAVITA MEDICAL & DIALYSIS CENTRE (EAST COAST)	32	0	0
DAVITA MEDICAL & DIALYSIS CENTRE (JURONG EAST)	39	0	0
DAVITA MEDICAL & DIALYSIS CENTRE (WOODLANDS)	14	0	0
DAVITA MEDICAL AND DIALYSIS CENTRE @ FARRER PARK MEDICAL CENTRE	46	0	0
DAVITA MEDICAL AND DIALYSIS CENTRE @ ROYAL SQUARE MEDICAL SUITES (NOVENA)	49	0	0
DIAVERUM CHOA CHU KANG DIALYSIS CENTRE	31	0	0
DIAVERUM DIALYSIS CENTRE TAMPINES (BLK 139 TAMPINES)	37	0	0
DIAVERUM FAJAR DIALYSIS CENTRE	45	0	0
DIAVERUM FARRER PARK DIALYSIS CENTRE	46	0	0
DIAVERUM KOVAN DIALYSIS CENTRE	43	0	0
DIAVERUM NOVENA DIALYSIS CENTRE	12	0	0
DIAVERUM PUNGGOL DIALYSIS CENTRE	44	0	0
DIAVERUM SENGKANG DIALYSIS CENTRE	41	0	0
DIAVERUM TAMPINES II DIALYSIS CENTRE	57	0	0
DIAVERUM TOA PAYOH DIALYSIS CENTRE	37	1	0
DIAVERUM TOWNER DIALYSIS CENTRE	0	0	0
DIAVERUM WOODLANDS DIALYSIS CENTRE	57	0	0
FIRSTLINE DIALYSIS CENTRE (BEDOK)	9	0	0
FRESENIUS KIDNEY CARE YISHUN DIALYSIS CLINIC	9	0	0
FRESENIUS KIDNEY CARE ANG MO KIO 128 DIALYSIS CLINIC	26	0	0
FRESENIUS KIDNEY CARE ANG MO KIO DIALYSIS CLINIC (BLK 422)	35	0	0
FRESENIUS KIDNEY CARE ANG MO KIO DIALYSIS CLINIC (BLK 443)	32	0	0
FRESENIUS KIDNEY CARE BEDOK DIALYSIS CLINIC	36	0	0
FRESENIUS KIDNEY CARE BEDOK RESERVOIR DIALYSIS CLINIC	65	0	0
FRESENIUS KIDNEY CARE BUANGKOK DIALYSIS CLINIC	50	0	0
FRESENIUS KIDNEY CARE BUKIT BATOK DIALYSIS CLINIC (BLK 213)	45	0	0
FRESENIUS KIDNEY CARE BUKIT MERAH CENTRAL DIALYSIS CLINIC	31	0	0
FRESENIUS KIDNEY CARE BUKIT MERAH DIALYSIS CLINIC	14	0	0
FRESENIUS KIDNEY CARE CLEMENTI DIALYSIS CLINIC	18	0	0
FRESENIUS KIDNEY CARE EAST COAST DIALYSIS CLINIC	37	0	0

FRESENIUS KIDNEY CARE FENGSHAN DIALYSIS CLINIC	7	0	0
FRESENIUS KIDNEY CARE JURONG BOON LAY DIALYSIS CLINIC (BLK 353)	39	0	0
FRESENIUS KIDNEY CARE JURONG EAST CENTRAL DIALYSIS CLINIC (BLK 104)	50	0	0
FRESENIUS KIDNEY CARE JURONG EAST DIALYSIS CLINIC (BLK 326)	44	0	0
FRESENIUS KIDNEY CARE KEMBANGAN DIALYSIS CLINIC	52	0	0
FRESENIUS KIDNEY CARE KHATIB DIALYSIS CLINIC	44	0	0
FRESENIUS KIDNEY CARE KOVAN DIALYSIS CLINIC	40	0	0
FRESENIUS KIDNEY CARE MARSILING DIALYSIS CLINIC	45	0	0
FRESENIUS KIDNEY CARE MT ELIZABETH DIALYSIS CLINIC	0	0	0
FRESENIUS KIDNEY CARE NAPIER DIALYSIS CLINIC	21	0	0
FRESENIUS KIDNEY CARE RENCI DIALYSIS CLINIC	35	0	0
FRESENIUS KIDNEY CARE SERANGOON DIALYSIS CLINIC	70	0	0
FRESENIUS KIDNEY CARE TAMPINES DIALYSIS CLINIC	42	0	0
FRESENIUS KIDNEY CARE TAMPINES WEST DIALYSIS CLINIC	45	0	0
FRESENIUS KIDNEY CARE TANGLIN DIALYSIS CLINIC	31	0	0
FRESENIUS KIDNEY CARE TECK WHYE DIALYSIS CLINIC	54	0	0
FRESENIUS KIDNEY CARE TIONG BAHRU DIALYSIS CLINIC	21	0	0
FRESENIUS KIDNEY CARE TOA PAYOH DIALYSIS CLINIC (BLK 92)	24	0	0
FRESENIUS KIDNEY CARE WHAMPOA DIALYSIS CLINIC	42	0	0
FRESENIUS KIDNEY CARE WOODLANDS DIALYSIS CLINIC	44	0	0
FRESENIUS KIDNEY CARE WOODLANDS PEAK DIALYSIS CLINIC	0	0	0
FRESENIUS KIDNEY CARE YISHUN RING DIALYSIS CLINIC	34	0	0
GLENEAGLES HOSPITAL	4	0	0
IMMANUEL DIALYSIS CENTRE (MAYFLOWER) PTE LTD	17	0	0
IMMANUEL DIALYSIS CENTRE PTE LTD (ANG MO KIO)	20	0	0
IMMANUEL DIALYSIS CENTRE PTE LTD (MT ALVERNIA)	31	0	0
IMMANUEL DIALYSIS CENTRE PTE LTD (WOODLANDS)	36	0	0
IMMANUEL DIALYSIS CENTRE PTE LTD (YISHUN)	18	0	0
KIDNEY THERAPEUTICS CENTRE PTE LTD	0	0	0
KIDNEYCARE DIALYSIS CENTRE @ PASIR RIS	47	0	0
KIDNEYCARE DIALYSIS CENTRE @ WEST COAST	32	0	0
KIDNEYCARE DIALYSIS CENTRE @ YISHUN	27	0	0
PACIFIC ADVANCE RENAL CARE (CHOA CHU KANG)	0	0	0
PACIFIC ADVANCE RENAL CARE (FAJAR)	0	0	0
PACIFIC ADVANCE RENAL CARE (SENG KANG)	0	0	0
PACIFIC ADVANCE RENAL CARE PTE LTD (PUNGGOL WAY)	0	0	0

PACIFIC ADVANCE RENAL CARE PTE LTD (WOODLANDS)	0	0	0
RAFFLES DIALYSIS CENTRE	20	0	0
RENAL HEALTH PTE LTD	56	0	0
RENAL LIFE (ALEXANDRA) DIALYSIS CENTRE PTE LTD	17	0	0
RENAL LIFE (HOUGANG) DIALYSIS CENTRE PTE LTD	20	0	0
RENAL LIFE (W) DIALYSIS CENTRE PTE LTD (BLK 207 BUKIT BATOK)	24	0	0
RENAL LIFE DIALYSIS CENTRE PTE LTD (BLK 463 JURONG WEST)	18	0	0
RENAL LIFE(PIONEER) DIALYSIS CENTRE PTE LTD	41	0	0
CENTRE FOR KIDNEY DISEASE PTE LTD (LUCKY PLAZA)	0	0	44
GRACE LEE RENAL AND MEDICAL CLINIC PTE LTD	0	2	7
KIDNEY & MEDICAL CENTRE	0	0	5
KIDNEY LIFE CENTRE	0	3	6
RAFFLES HOSPITAL	0	2	3
ROGER KIDNEY CLINIC	0	0	7
SH TAN KIDNEY & MEDICAL CLINIC	0	2	3
STEPHEW CHEW CENTRE FOR KIDNEY DISEASE AND HYPERTENSION (MAH)	0	0	16
STEPHEW CHEW CENTRE FOR KIDNEY DISEASE AND HYPERTENSION (MEH)	0	0	2
T.G. NG KIDNEY & MEDICAL CENTRE	0	0	2
TAL DIALYSIS CLEMENTI	35	0	0
THE KIDNEY & TRANSPLANT PRACTICE	0	6	4
THE KIDNEY CLINIC PTE LTD	0	0	11
THE KIDNEY HEALTH CLINIC PTE LTD	0	0	2
THE SINGAPORE CLINIC FOR KIDNEY DISEASES	0	1	3
WU NEPHROLOGY & MEDICAL CLINIC (WU MEDICAL CLINIC PTE LTD)	0	0	34
Subtotal	**2600**	**17**	**149**
Grand total	**7988**	**1208**	**1639**