Singapore Renal Registry
Annual Report 2022

National Registry of Diseases Office

January 2024

Suggested Source Citation:
National Registry of Diseases Office, Health Promotion Board, Singapore.

Acknowledgement

This report was produced with joint effort from the following staff of Health Promotion Board.

National Registry of Diseases Office

Registry Coordinators	Ms Lynn Khor Ms Ang Ghim Sin Ms Grace Cai Ms Maureen Ng Dr Win Nyunt
Data Manager	Mr Augustine Ng
Senior Manager	Mr Chen Xiaoyang
Epidemiologist	Ms Kuo Simin
Deputy Director	Dr Foo Ling Li
Director	Dr Karen Cheong

Contents

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 significantly from 407.8 per million population (pmp) in 2012 to 540.5 pmp in 2021. While the age-standardised incidence rate (ASIR) of CKD5 remained stable and ranged between 274.0 pmp and 278.1 pmp in 2012 to 2021, the ASIR of definitive dialysis increased significantly from 169.6 pmp in 2012 to 189.1 pmp in 2022. The age-standardised prevalence rate (ASPR) of definitive dialysis also increased significantly from 949.0 pmp in 2012 to 1,161.8 pmp in 2022.

Males outnumbered females in both the incidence and prevalence rates of dialysis. In 2022, the ASIR was 233.7 pmp for males and 147.7 pmp for females, while the ASPR was 1,375.5 pmp for males and 964.9 pmp for females. The incidence and prevalence rates of dialysis were higher among Malays than Chinese and Indians. In 2022, the ASIR was 150.0 pmp for Chinese, 458.5 pmp for Malays and 182.8 pmp for Indians, while the ASPR was 906.4 pmp for Chinese, 2,967.6 pmp for Malays and 1,144.9 pmp for Indians. Most dialysis patients were on haemodialysis (HD). 81.7% of the new patients and 87.2% of the prevalent patients were on HD in 2022. 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. 64.6% of the new dialysis patients and 56.0% of the prevalent dialysis patients had DN in 2022. Cardiac events and infections were the two most common causes of death among prevalent patients on dialysis. 36.8% of the deaths in 2022 were due to cardiac events, while 31.9% were due to infection. After adjusting for demographics, etiology and co-morbidities, the risk of death was 1.5 times higher for patients on peritoneal dialysis (PD) compared to those on HD. This is mainly because patients who were older and/or with medical conditions (besides the co-morbidities captured by the Singapore Renal Registry) were preferentially placed on PD, which is a gentler therapy than 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 significantly 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. 97.0% of the HD patients had thrice weekly dialysis in 2022. Urea was well managed in 97.4% of the HD patients and 43.3% of the PD patients based on their urea reduction ratio or fractional clearance of urea in 2022. Anaemia was well managed in 72.9% of the HD patients and 57.5% of the PD patients based on their haemoglobin level in 2022. Bone metabolism was well managed in 74.5%, 56.9% and 25.7% of the HD patients and 59.4%, 53.8% and 24.8% of the PD patients based on their calcium level, phosphate level and intact parathyroid hormone level respectively in 2022.

The ASIR of kidney transplant fluctuated over the years between 2012 and 2022 due to the small number of transplants done each year. However, the ASPR of kidney transplant remained stable during the same period as survival among the transplant patients was high. The ASIR was 15.1 pmp, while the ASPR was 252.2 pmp in 2022.

Males outnumbered females in both the incidence and prevalence rates of kidney transplant. In 2022, the ASIR was 18.2 pmp for males and 12.0 pmp for females, while the ASPR was 274.6 pmp for males and 231.4 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 2022, the ASIR was 12.4 pmp for Chinese, 20.2 pmp for Malays and 17.3 pmp for Indians, while the ASPR was 253.6 pmp for Chinese, 238.4 pmp for Malays and 219.8 pmp for Indians. Most transplants were performed locally. 94.8% of the transplants in 2022 were performed in Singapore. Glomerulonephritis (GN) was the main cause of CKD5 among patients with transplant. 51.3% of the new transplant patients and 65.5% of the prevalent transplant patients had GN in 2022.

Patients with kidney transplants from living donors had better survival (5-year graft survival 93.8%, 5-year patient survival 96.0%) than those with kidney transplants from deceased donors (5-year graft survival 85.7%, 5-year patient survival 91.1%). After adjusting for demographics, etiology and co-morbidities, the risk of death was lower for patients with transplant, be it from living or deceased donor, 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, 8.5% (1 in 12) of 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 were 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/resources-statistics/reports/national-population-health-survey-2022 Accessed on 4 October 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 healthcare institutions in 2010, after legislation mandating notification of CKD5 from all healthcare institutions was put in place by the Ministry of Health.

Data sources

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 2023 by matching the patients' unique National Registration Identity Card number with information from the Death Registry.

[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 2012 to 2022, as they stood on 24 May 2023. Statistics on prevalence and survival included patients since the start of the SRR in 1999. Detailed definition of each indicator is elaborated 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 9 May 2023.
[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 2018 to 2022. 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 2018-2020, but rose slightly thereafter. Deaths among transplant patients and number of prevalent transplant patients remained stable over the years.

Table 5.1.1: Stock and flow in 2018 – 2022

	2018	2019	2020	2021	2022
Incidence					
Definitive dialysis	1254	1208	1335	1411	1420
Transplant	114	105	50	74	76
Death					
Definitive dialysis	915	908	957	1030	1288
Transplant	39	33	30	34	41
Prevalence					
Definitive dialysis	7406	7765	8220	8671	8878
Transplant	1602	1620	1610	1612	1611

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 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 2022, most of the prevalent HD patients were last followed up at dialysis centres run by the Voluntary Welfare Organisations (VWO, 62.8%), followed by the private clinics and dialysis centres (35.2%), then the public hospitals and affiliated dialysis centres (2.0%).

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 (98.9%) were last followed up at the public hospitals and affiliated dialysis centres in 2022.

Similarly, follow-up among transplant patients is typically for consultation with their nephrologists, where transplant was done. Almost all the prevalent transplant patients (90.9%) were followed up at the public hospitals and affiliated dialysis centres in 2022.

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 2022

	HD		PD		Transplant	
	Number	%	Number	%	Number	%
Public hospitals and affiliated dialysis centres	158	2.0	1120	98.9	1464	90.9
Dialysis centres under Voluntary Welfare Organisations	4860	62.8	0	0.0	0	0.0
Private clinics and dialysis centres	2727	35.2	13	1.1	147	9.1
Overseas	0	0.0	0	0.0	0	0.0
Total	7745	100	1133	100	1611	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.

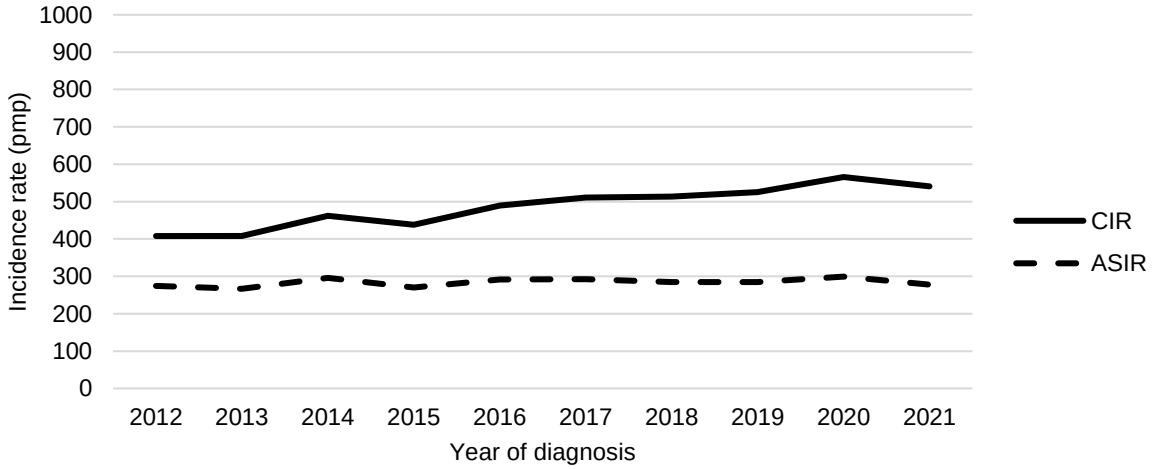
As the registry monitors the patient's eGFR readings for at least six months before accepting a case as CKD5 to allow for accurate case ascertainment, all statistics related to new CKD5 patients for 2022 are not shown in this section.

The number of new patients diagnosed with CKD5 increased from 1,557 in 2012 to 2,155 in 2021, an increase of almost 40% (Table 5.2.1 and Figure 5.2.1). Correspondingly, the CIR increased significantly from 407.8 pmp in 2012 to 540.5 pmp in 2021 ($p<0.001$). However, the ASIR remained stable and ranged between 266.7 pmp and 299.2 pmp during the same period. 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
2012	1557	407.8	274.0
2013	1570	408.4	266.7
2014	1788	461.9	295.6
2015	1711	438.4	270.3
2016	1926	489.6	291.1
2017	2025	510.6	292.8
2018	2050	513.2	285.0
2019	2116	525.6	284.6
2020	2288	565.7	299.2
2021	2155	540.5	278.1
P for trend	-	<0.001	0.220

Figure 5.2.1: Incidence rate (pmp) of CKD5



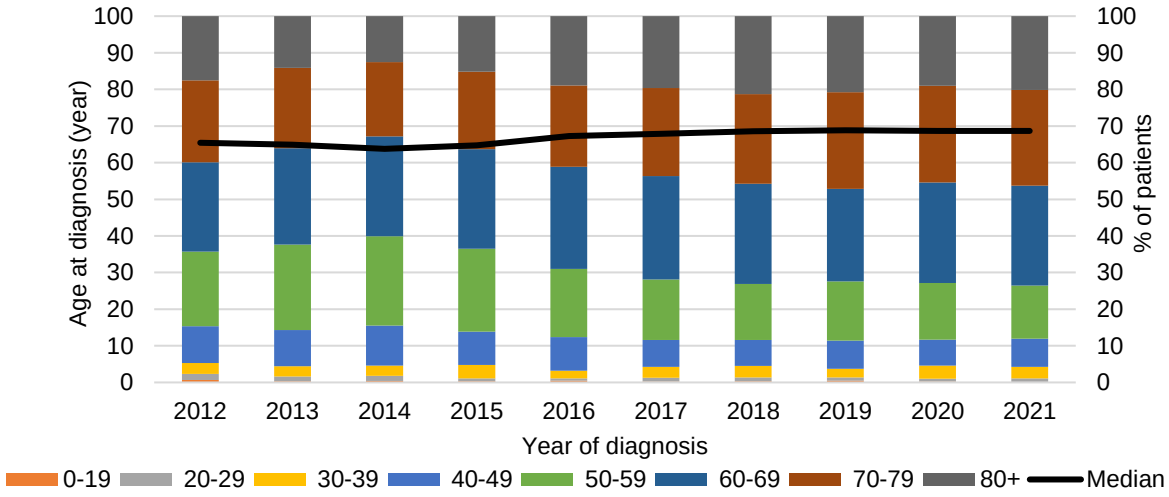
The age-specific incidence rate of CKD5 did not show significant changes over the years, except for those aged 30-39 years whereby the age-specific incidence rate increased from 75.5 to 116.9 pmp in the past decade (Table 5.2.2).

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
2012	10	0.6	11.3	26	1.7	50.1	46	3.0	75.5	157	10.1	249.3
2013	5	0.3	5.7	21	1.3	40.2	43	2.7	71.4	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	83	3.6	139.0	161	7.0	263.5
2021	4	0.2	5.1	19	0.9	36.8	69	3.2	116.9	166	7.7	280.0
P for trend	-	-	0.544	-	-	0.430	-	-	0.022	-	-	0.813
Year of diagnosis	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2012	317	20.4	544.5	380	24.4	1108.5	348	22.4	2023.3	273	17.5	3518.0
2013	367	23.4	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	537	27.9	1193.7	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	342	16.2	562.1	534	25.2	1067.7	558	26.4	2280.1	440	20.8	3804.4
2020	355	15.5	589.8	628	27.4	1221.7	603	26.4	2310.4	435	19.0	3508.8
2021	312	14.5	534.1	588	27.3	1135.1	562	26.1	2063.9	435	20.2	3312.7
P for trend	-	-	0.194	-	-	0.811	-	-	0.046	-	-	0.148

The median age at diagnosis of CKD5 increased from 65.5 years in 2012 to 68.7 years in 2021; the percentage of CKD5 patients aged 60 years and above also increased from 64.3% in 2012 to 73.6% in 2021 (Figure 5.2.2a).

Figure 5.2.2a: Median age (year) 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

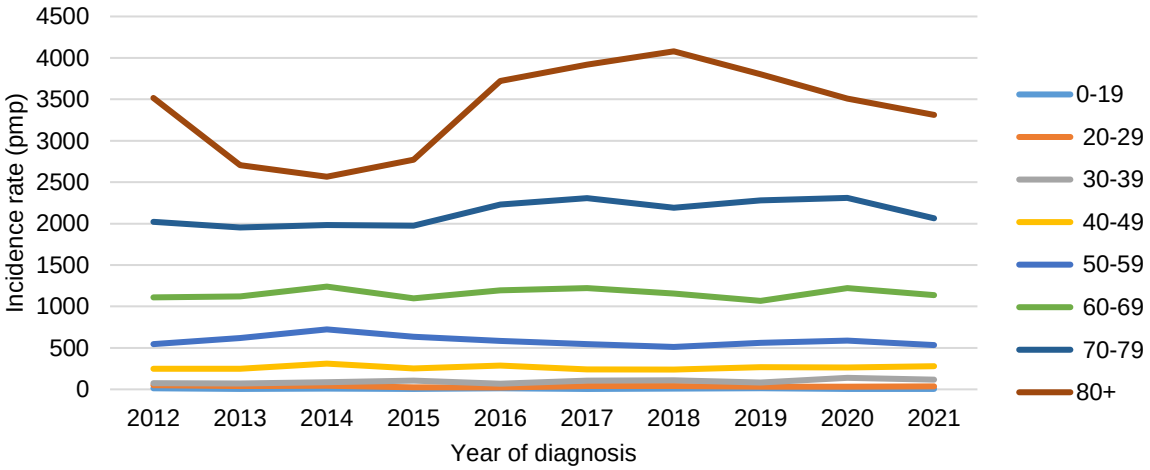
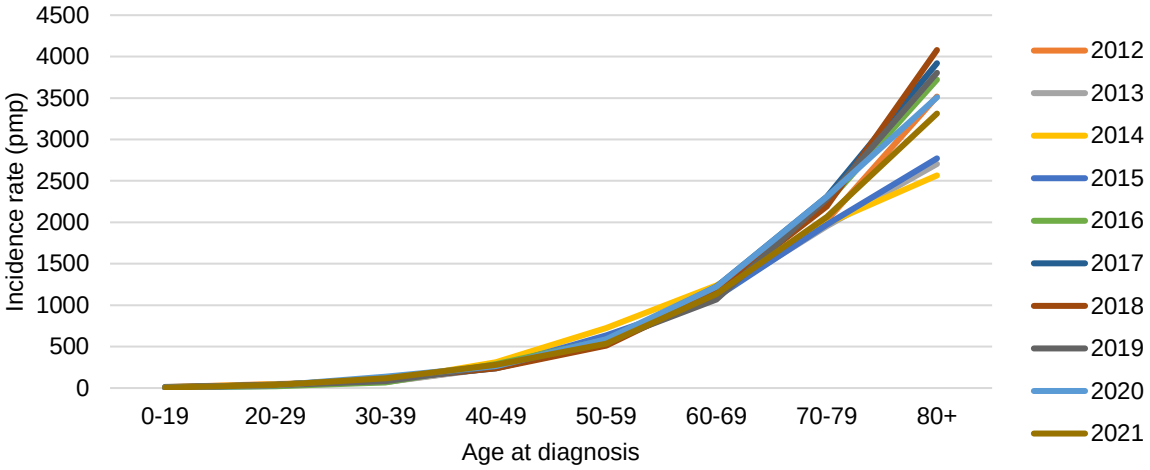


Figure 5.2.3: Age-specific incidence rate (pmp) of CKD5 across age groups



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 and Figure 5.2.4). In 2021, the ASIR was 332.2 pmp and 227.7 pmp for males and females respectively. While there was a significant increase in the ASIR of CKD5 among males (p=0.028), that of females remained relatively stable. 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 in 2022[10].

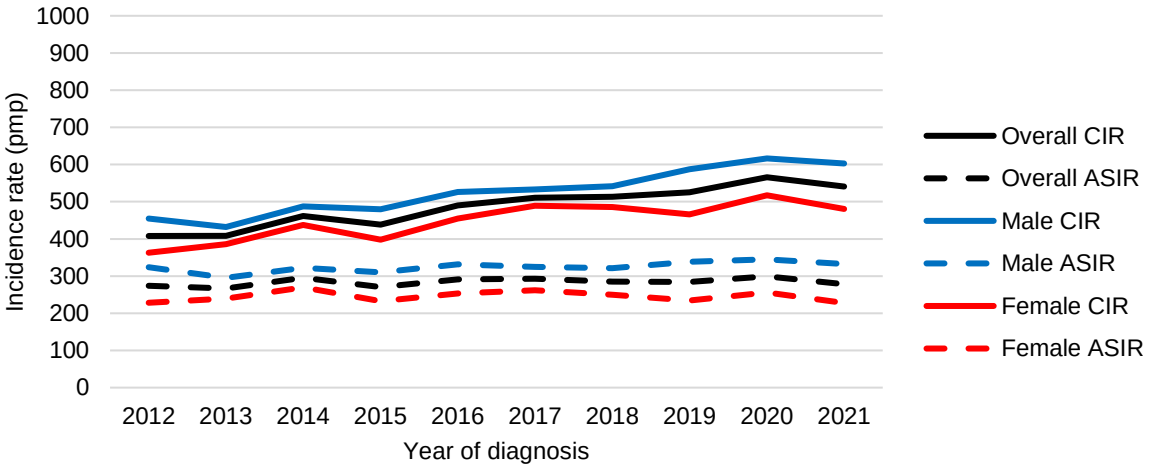
Table 5.2.3: Incidence number and rate (pmp) of CKD5 by sex

Male				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2012	854	54.8	454.3	323.5
2013	817	52.0	432.0	295.3
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	1060	51.7	542.0	321.0
2019	1157	54.7	587.5	338.5
2020	1219	53.3	616.4	345.0
2021	1178	54.7	603.1	332.2
P for trend	-	-	<0.001	0.028
Female				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2012	703	45.2	362.8	228.3
2013	753	48.0	385.5	239.2
2014	861	48.2	437.4	269.5

[10] National Population Health Survey 2022 (Household Interview and Health Examination). Ministry of Health, Singapore. https://www.moh.gov.sg/resources-statistics/reports/national-population-health-survey-2022 Accessed on 4 October 2023.

2015	791	46.2	398.3	232.4
2016	911	47.3	454.6	253.1
2017	989	48.8	489.1	261.9
2018	990	48.3	485.7	250.2
2019	959	45.3	466.3	234.6
2020	1069	46.7	517.3	255.6
2021	977	45.3	480.4	227.7
P for trend	-	-	0.001	0.998

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



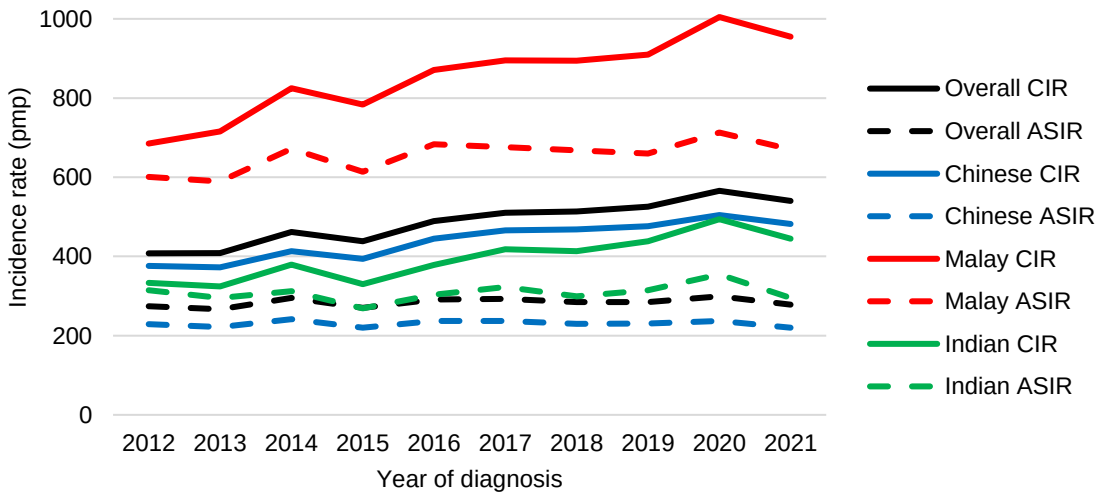
Over the past decade, the ASIRs of CKD5 were consistently higher among Malays than Chinese and Indians (Table 5.2.4 and Figure 5.2.5). In 2021, the ASIR among Malays was 670.4 pmp, which was 3-fold higher compared to Chinese (220.1 pmp) and more than 2-fold higher compared to Indians (295.4 pmp). It is also noteworthy that while the ASIRs for Chinese and Indians remained stable over the years, the ASIR for Malays increased significantly (p=0.016).

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

Chinese				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2012	1065	68.4	376.1	228.8
2013	1063	67.7	372.5	221.6
2014	1189	66.5	413.7	241.5
2015	1142	66.7	393.8	220.1
2016	1300	67.5	444.7	236.9
2017	1373	67.8	465.7	236.9
2018	1390	67.8	468.1	229.7
2019	1426	67.4	476.3	230.5
2020	1517	66.3	504.5	236.9
2021	1427	66.2	482.1	220.1
P for trend	-	-	<0.001	0.984
Malay				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2012	349	22.4	685.1	601.0

2013	367	23.4	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	479	23.4	894.0	668.3
2019	492	23.3	909.8	659.9
2020	548	24.0	1004.6	712.9
2021	520	24.1	955.1	670.4
P for trend	-	-	<0.001	0.016
Indian				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2012	117	7.5	333.3	314.5
2013	114	7.3	324.3	295.2
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	149	7.3	413.3	299.5
2019	159	7.5	438.5	314.6
2020	179	7.8	494.1	354.5
2021	158	7.3	445.2	295.4
P for trend	-	-	<0.001	0.409

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



5.3 Incidence of ever-started dialysis

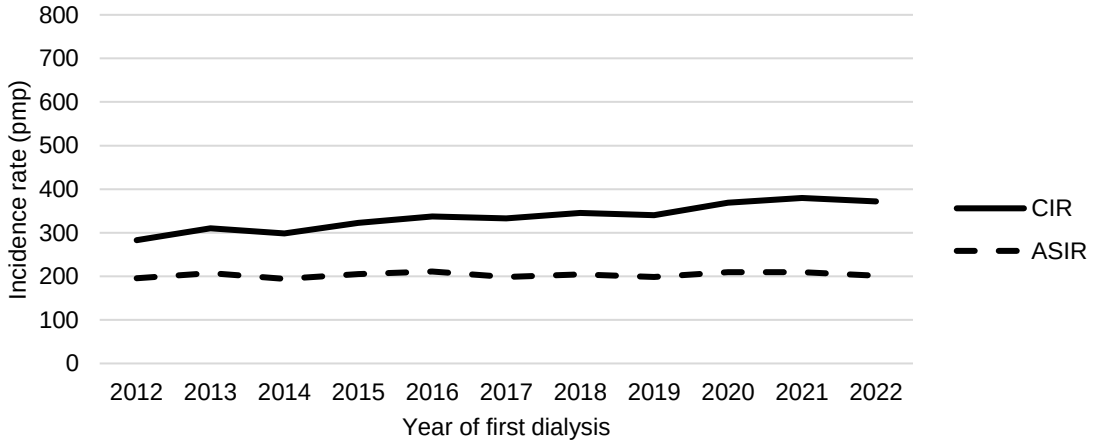
The incidence rate of ever-started dialysis in each year was calculated by taking the number of new patients who ever-started dialysis in a year, divided by the number of Singapore residents in the same year. The modality was based on the first dialysis. Patients were categorised into 10-year age groups 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 1,080 in 2012 to 1,515 in 2022, a 40% increase in 10 years (Table 5.3.1 and Figure 5.3.1). Correspondingly, the CIR increased significantly from 282.9 pmp in 2012 to 371.9 pmp in 2022 (p<0.001). However, the ASIR remained stable and ranged between 194.1 pmp and 210.9 pmp during the same period.

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

Year of first dialysis	Number	CIR	ASIR
2012	1080	282.9	195.9
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	1491	368.7	209.6
2021	1514	379.7	209.8
2022	1515	371.9	201.3
P for trend	-	<0.001	0.325

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



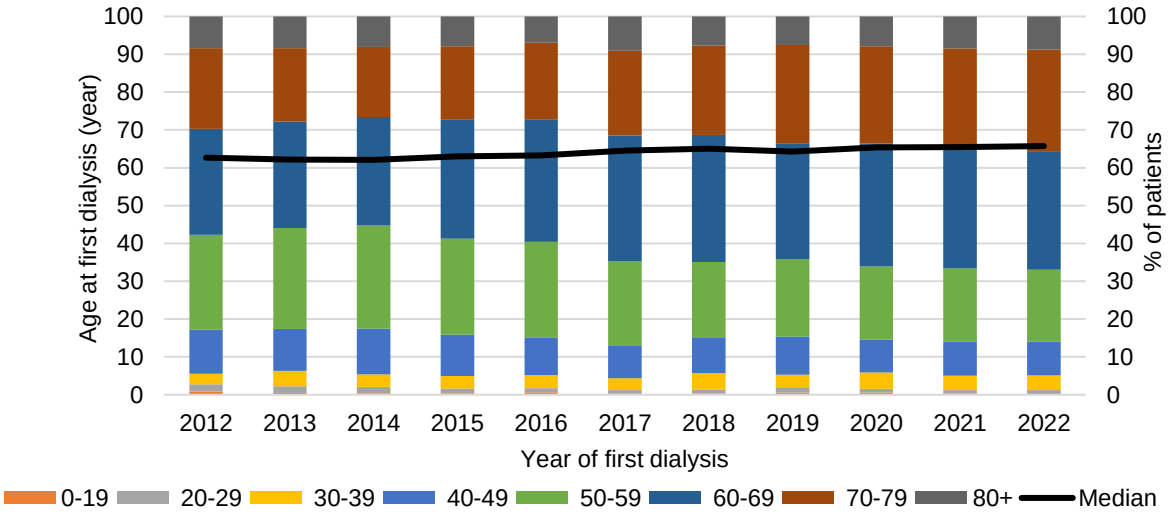
The age-specific incidence rate of ever-started dialysis increased significantly for those aged 30 to 39 years (p=0.003) and 70 to 79 years (p=0.016), but it dropped for those aged 80 years and above (p=0.015) (Table 5.3.2). Those aged 30 to 39 years exhibited the largest change, with a nearly twofold increase in their age-specific incidence rate.

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
2012	9	0.8	10.2	21	1.9	40.4	30	2.8	49.3	126	11.7	200.1
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	130	8.7	212.8
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	1.3	37.0	59	3.9	97.0	136	9.0	225.1
P for trend	-	-	0.843	-	-	0.250	-	-	0.003	-	-	0.198
Year of first dialysis	**Age 50-59**			**Age 60-69**			**Age 70-79**			**Age 80+**		
	Number	**%**	**CIR**	**Number**	**%**	**CIR**	**Number**	**%**	**CIR**	**Number**	**%**	**CIR**
2012	271	25.1	465.5	302	28.0	881.0	230	21.3	1337.2	91	8.4	1172.7
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	484	32.5	941.6	383	25.7	1467.4	118	7.9	951.8
2021	291	19.2	498.1	477	31.5	920.8	404	26.7	1483.6	128	8.5	974.8
2022	287	18.9	484.1	472	31.2	880.7	410	27.1	1392.8	132	8.7	971.8
P for trend	-	-	0.270	-	-	0.771	-	-	0.016	-	-	0.015

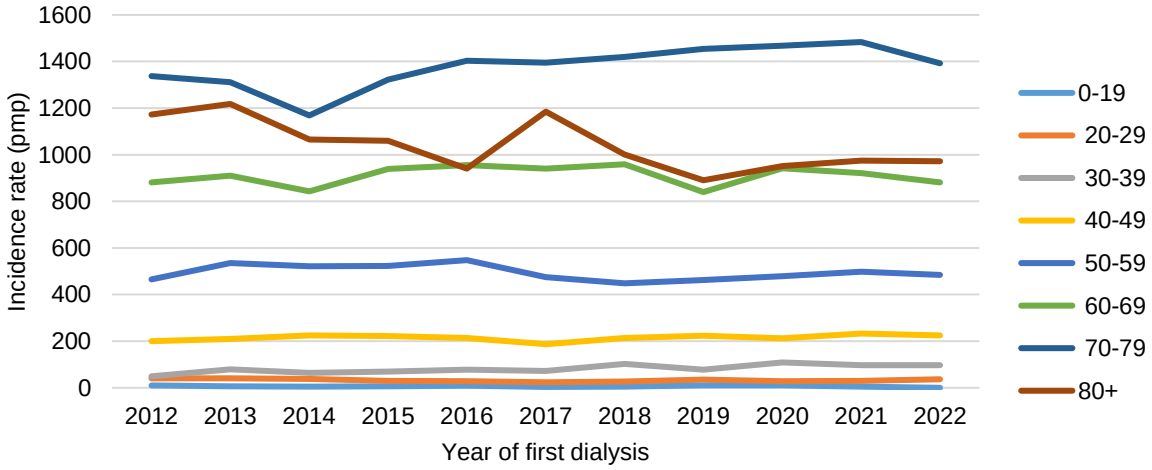
The median age at first dialysis increased from 62.7 years in 2012 to 65.7 years in 2022 (Figure 5.3.2a).

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



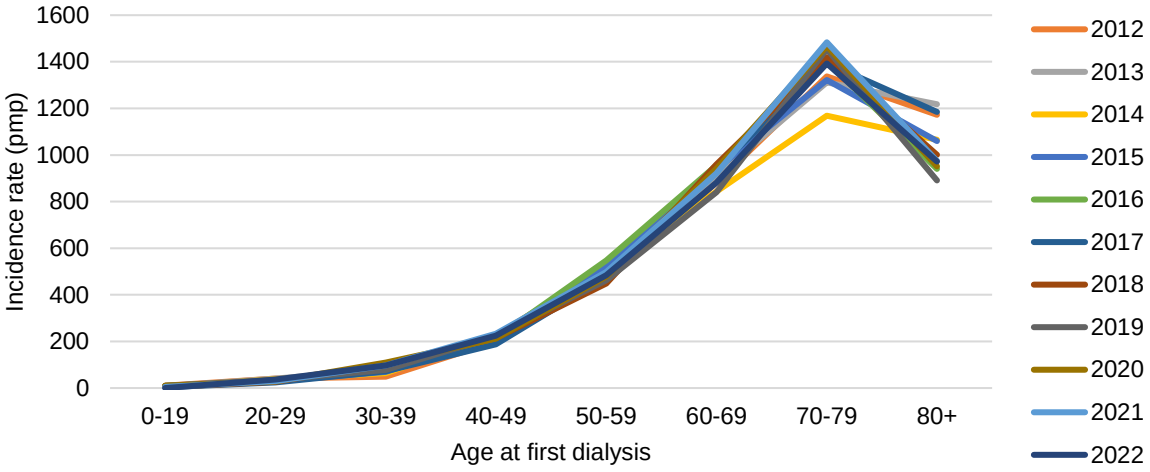
The age-specific incidence rates of ever-started dialysis increased with age, and it was highest for those aged 70 to 79 years (Figure 5.3.2b, Figure 5.3.3). However, a decline was observed among those aged 80 years or older for all the years. Possible reasons for this decline could be elderly patients passing away before their first planned dialysis or refusing dialysis as studies have shown that dialysis offers little advantage in improving survival, especially among those with pre-existing co-morbidities[11].

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



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

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



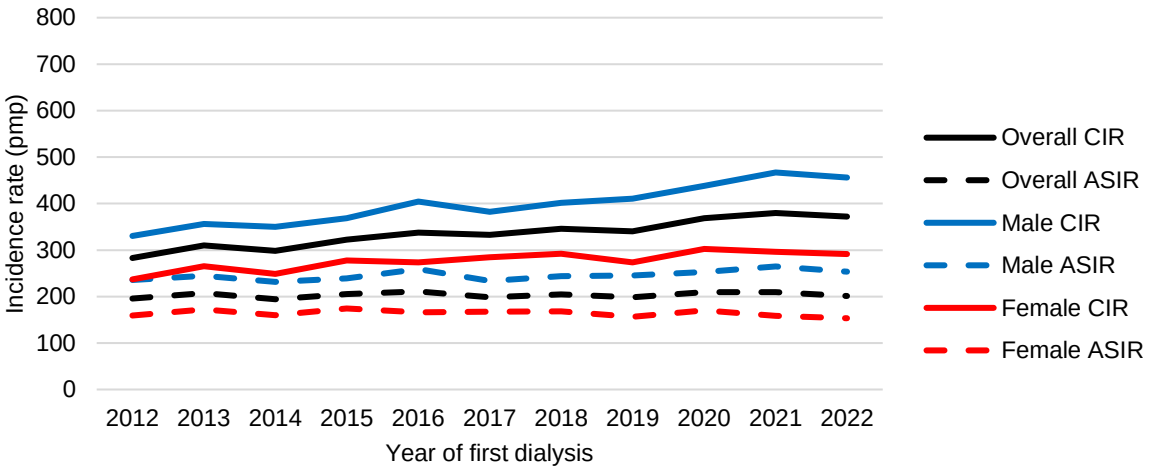
The ASIRs of ever-started dialysis were consistently higher among males than females across the years (Table 5.3.3 and Figure 5.3.4). In 2022, the ASIR was 253.5 pmp and 153.3 pmp for males and females respectively. Similar to the sex trends of CKD5 incidence, the ASIR of dialysis initiation among males increased significantly (p=0.030), while no significant changes were observed in that of females.

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

Male				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	621	57.5	330.4	235.4
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	808	59.0	410.3	245.0
2020	866	58.1	437.9	252.7
2021	912	60.2	466.9	264.7
2022	908	59.9	456.2	253.5
P for trend	-	-	<0.001	0.030

Female				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	459	42.5	236.9	158.9
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	562	41.0	273.2	156.1
2020	625	41.9	302.4	170.2
2021	602	39.8	296.0	158.7
2022	607	40.1	291.4	153.3
P for trend	-	-	0.001	0.266

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

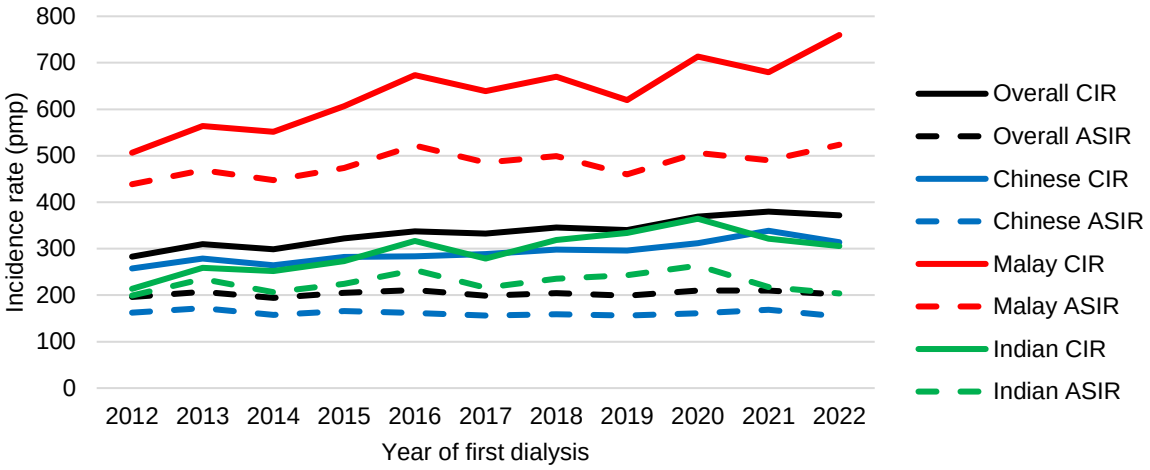


The ASIRs of ever-started dialysis were consistently higher among Malays than Chinese and Indians across the years (Table 5.3.4 and Figure 5.3.5). In 2022, the ASIR was 154.2 pmp, 523.6 pmp and 203.7 pmp for Chinese, Malays and Indians respectively. While the ASIRs for Malays increased significantly over the years (p=0.022), the ASIRs for Chinese and Indians remained stable.

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

Chinese				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	729	67.5	257.5	162.0
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	938	62.9	312.0	161.3
2021	1002	66.2	338.5	168.8
2022	948	62.6	314.0	154.2
P for trend	-	-	<0.001	0.301
Malay				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	258	23.9	506.5	438.7
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	335	24.5	619.5	460.1
2020	389	26.1	713.1	506.3
2021	370	24.4	679.6	490.2
2022	421	27.8	759.8	523.6
P for trend	-	-	<0.001	0.022
Indian				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	75	6.9	213.7	199.2
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	121	8.8	333.7	242.7
2020	132	8.9	364.4	263.4
2021	114	7.5	321.2	217.3
2022	112	7.4	305.7	203.7
P for trend	-	-	0.002	0.553

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



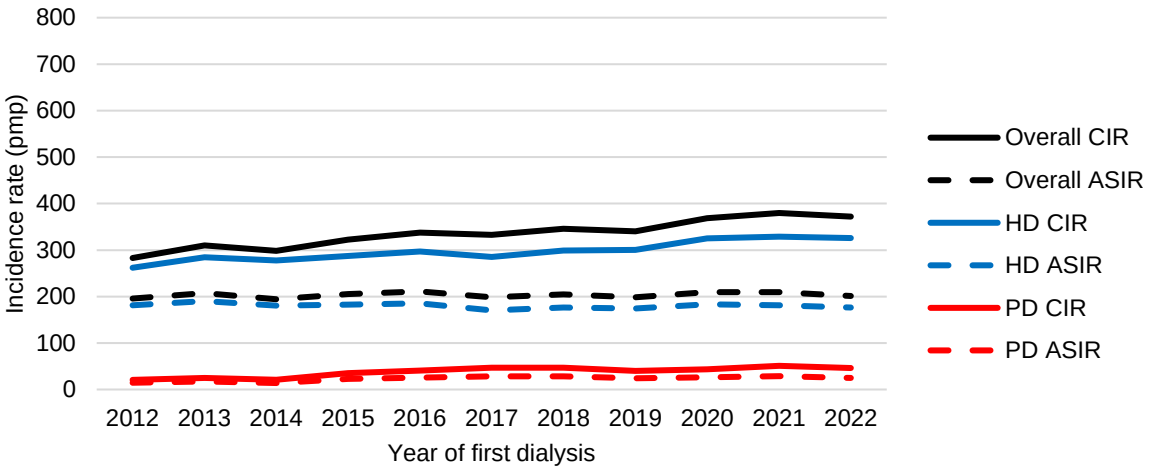
The ASIRs of ever-started dialysis were consistently higher among HD than PD across the years, as about 90% of those who initiated dialysis did so with HD (Table 5.3.5 and Figure 5.3.6). In 2022, the ASIR was 176.5 pmp and 24.8 pmp for HD and PD respectively. While the ASIR for PD increased significantly over the years (p=0.006), the ASIR for HD remained stable. 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.

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

HD				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	1000	92.6	261.9	181.0
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	1316	88.3	325.4	183.4
2021	1311	86.6	328.8	181.1
2022	1328	87.7	326.0	176.5
P for trend	-	-	<0.001	0.221

PD				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	80	7.4	21.0	14.8
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	175	11.7	43.3	26.2
2021	203	13.4	50.9	28.7
2022	187	12.3	45.9	24.8
P for trend	-	-	0.001	0.006

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 about 54% from 921 in 2012 to 1,420 in 2022 (Table 5.4.1 and Figure 5.4.1). Correspondingly, the CIR increased significantly from 241.2 pmp in 2012 to 348.6 pmp in 2022 ($p<0.001$). The rise in ASIR from 169.6 pmp in 2012 to 189.1 pmp in 2022 was also significant ($p=0.001$), albeit of a smaller magnitude than the rise in CIR. The 2019 Global Kidney Health Atlas (GKHA) cross-sectional survey of 160 nations showed that the incidence of treated CKD5[12] 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[13].

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 2020, Singapore had the third highest incidence of treated CKD5 in the world among countries included in the analysis, behind Taiwan and the United States[14].

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

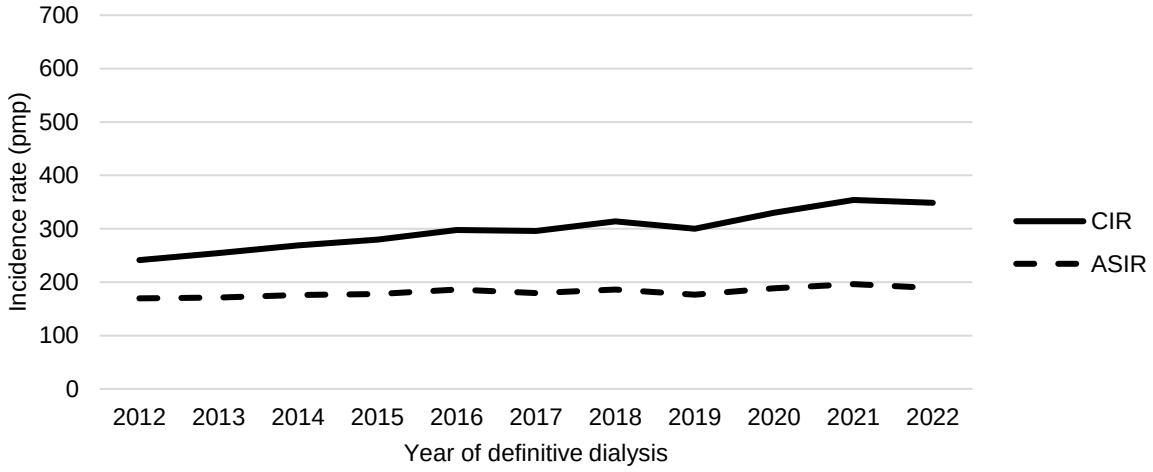
[13] Thurlow J S et al. Global Epidemiology of End-Stage Kidney Disease and Disparities in Kidney Replacement Therapy. Am J Nephrol 2021;52:98–107.

[14] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/11-international-comparisons. Accessed 24 August 2023.

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

Year of definitive dialysis	Number	CIR	ASIR
2012	921	241.2	169.6
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	1335	330.1	188.5
2021	1411	353.9	196.2
2022	1420	348.6	189.1
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 to 39 years (p<0.001), 40 to 49 years (p=0.026) and 70 to 79 years (p=0.005), with the former registering the largest increase in dialysis incidence, doubling over the past decade (Table 5.4.2). Notwithstanding this, majority of incident dialysis patients were found among the older age bands, especially those 60 years and above – increasing from 57.3% in 2012 to 65.8% in 2022. Data from the USRDS also showed that growth of treated CKD5[15] incidence was highest among the older age bands (especially those above 65 years and above) across different countries[16].

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

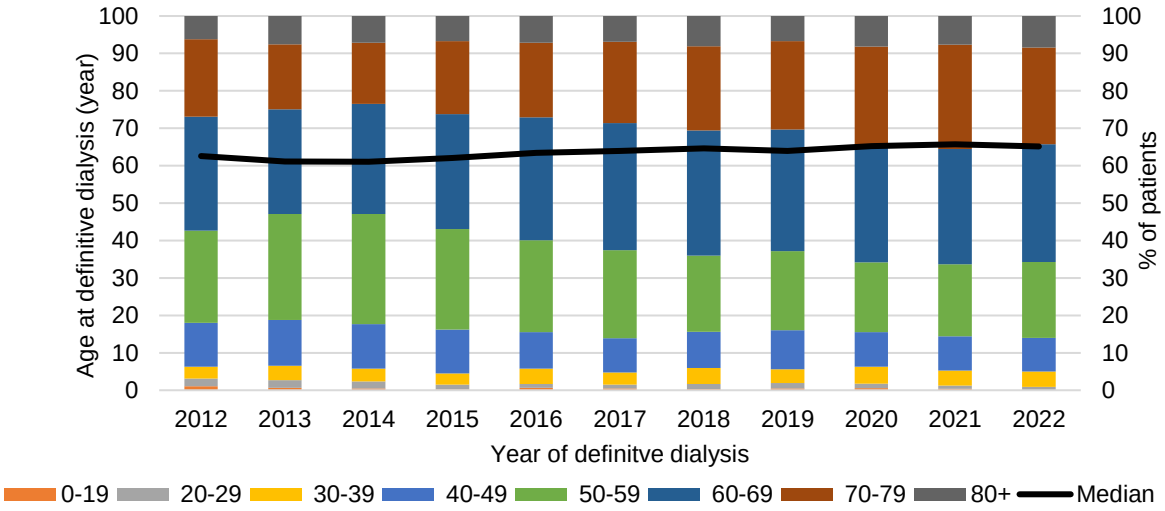
[16] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/11-international-comparisons. Accessed 24 August 2023.

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
2012	10	1.1	11.3	19	2.1	36.6	29	3.1	47.6	108	11.7	171.5
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	0.9	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	128	9.0	211.9
P for trend	-	-	0.949	-	-	0.084	-	-	<0.001	-	-	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
2012	227	24.6	389.9	280	30.4	816.8	191	20.7	1110.5	57	6.2	734.5
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	18.7	413.7	420	31.5	817.1	350	26.2	1341.0	109	8.2	879.2
2021	271	19.2	463.9	434	30.8	837.8	394	27.9	1446.9	108	7.7	822.5
2022	287	20.2	484.1	447	31.5	834.1	368	25.9	1250.1	119	8.4	876.1
P for trend	-	-	0.944	-	-	0.155	-	-	0.005	-	-	0.620

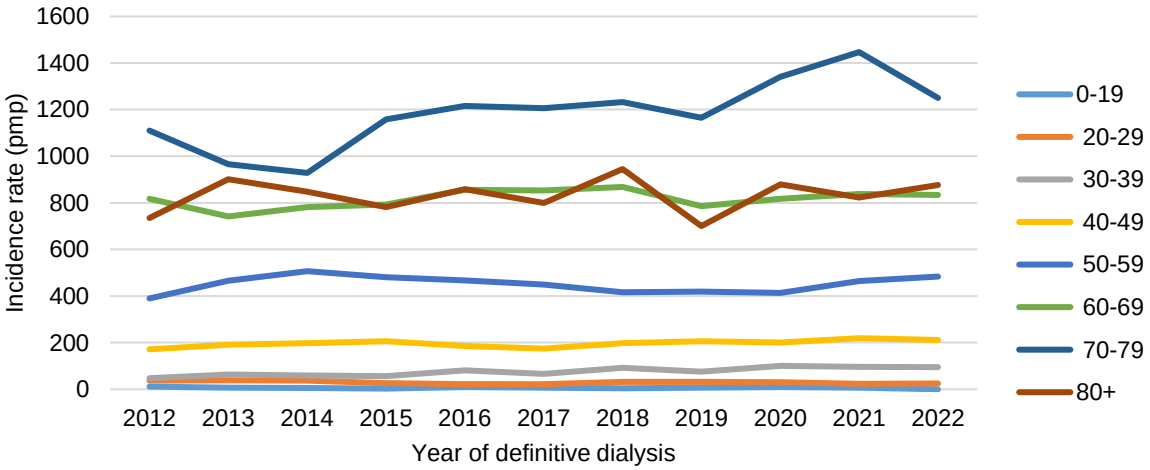
The median age at definitive dialysis increased from 62.6 years in 2012 to 65.2 years in 2022 (Figure 5.4.2a).

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



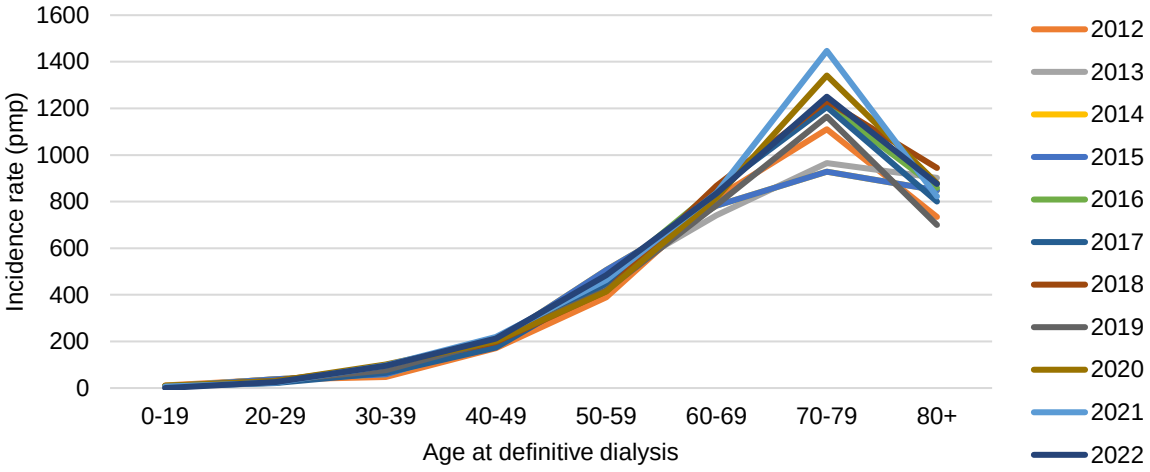
Similar to the trends for ever-started dialysis incidence, the age-specific incidence rates of definitive dialysis increased with age (Figure 5.4.2b, Figure 5.4.3) It peaked for those aged 70 to 79 years, and then declined for those aged 80 years or older as studies have shown that dialysis offers little advantage in improving survival, especially among elderly patients with pre-existing co-morbidities[17].

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



[17] 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



The ASIRs of definitive dialysis were consistently higher among males than females across the years (Table 5.4.3 and Figure 5.4.4). In 2022, the ASIR was 233.7 pmp and 147.7 pmp for males and females respectively. The ASIR increased significantly over the years for males (p<0.001), but not for females. Like trends found in other high-income countries, males had a 1.2- to 1.5-fold higher incidence of dialysis across the years[18].

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

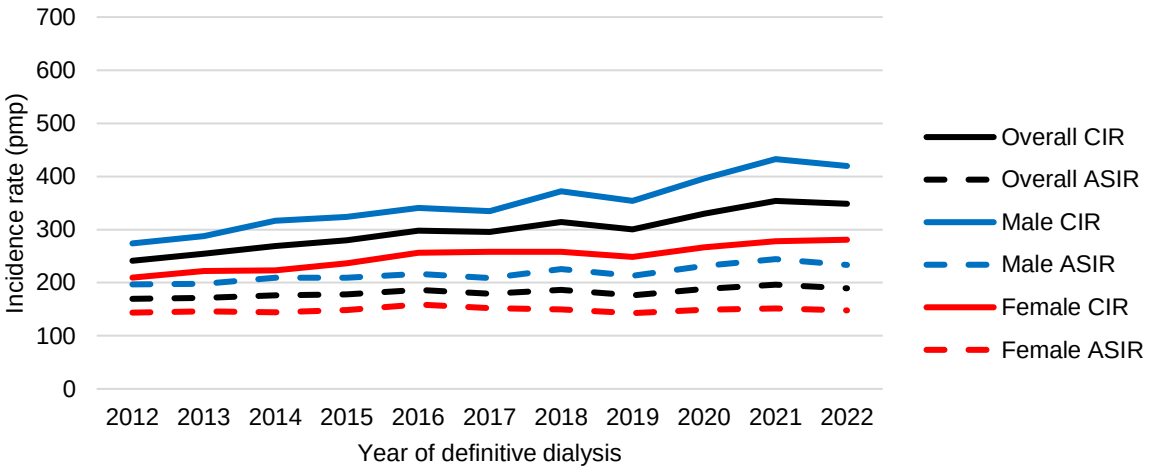
Male				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	515	55.9	274.0	196.8
2013	544	55.6	287.6	198.1
2014	602	57.8	316.4	209.2
2015	621	56.9	324.0	209.6
2016	657	56.1	340.5	216.6
2017	651	55.5	335.0	208.4
2018	728	58.1	372.2	225.8
2019	697	57.7	353.9	212.7
2020	784	58.7	396.4	231.4
2021	845	59.9	432.6	244.4
2022	835	58.8	419.6	233.7
P for trend	-	-	<0.001	<0.001

Female				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	406	44.1	209.5	143.7
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

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

2019	511	42.3	248.4	142.7
2020	551	41.3	266.6	149.1
2021	566	40.1	278.3	151.7
2022	585	41.2	280.8	147.7
P for trend	-	-	<0.001	0.474

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

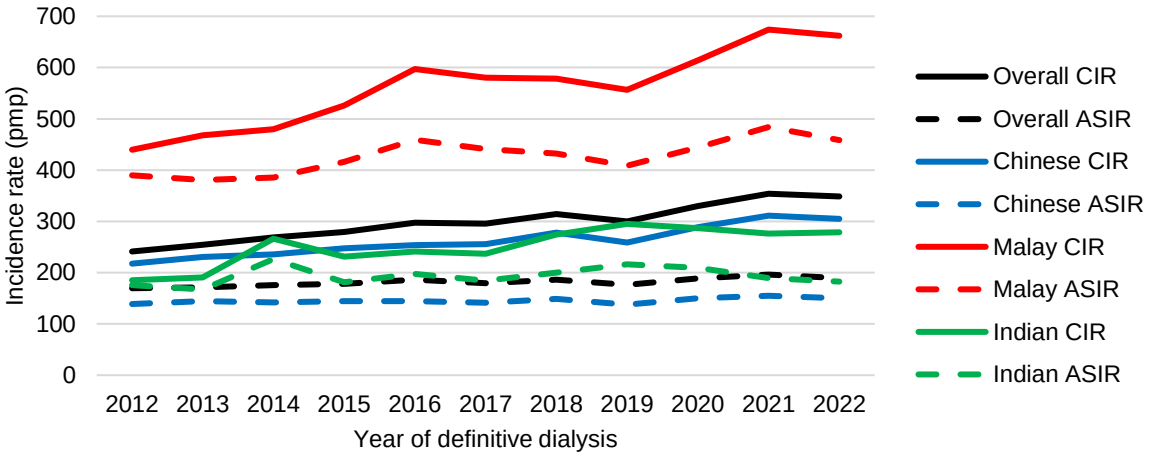


The ASIRs of definitive dialysis were consistently higher among Malays than Chinese and Indians across the years (Table 5.4.4 and Figure 5.4.5). In 2022, the ASIR was 150.0 pmp, 458.5 pmp and 182.8 pmp for Chinese, Malays and Indians respectively. While the ASIRs for Malays (p=0.003) and Chinese (p=0.035) increased significantly over the years, the ASIRs 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**
2012	616	66.9	217.5	138.7
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	868	65.0	288.7	149.8
2021	921	65.3	311.1	154.9
2022	920	64.8	304.7	150.0
P for trend	-	-	<0.001	0.035
Malay				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	224	24.3	439.7	389.9
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	335	25.1	614.1	444.0
2021	367	26.0	674.1	484.0
2022	367	25.8	662.3	458.5
P for trend	-	-	<0.001	0.003
Indian				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	65	7.1	185.2	175.7
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	104	7.8	287.1	209.2
2021	98	6.9	276.1	189.2
2022	102	7.2	278.4	182.8
P for trend	-	-	0.002	0.425

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 2012 to 2022 (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[19]. 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 and Figure 5.4.6). In 2022, the ASIR was 153.2 pmp and 35.9 pmp for HD and PD respectively. While the ASIR for PD increased significantly over the years (p=0.040), the ASIR for HD remained stable.

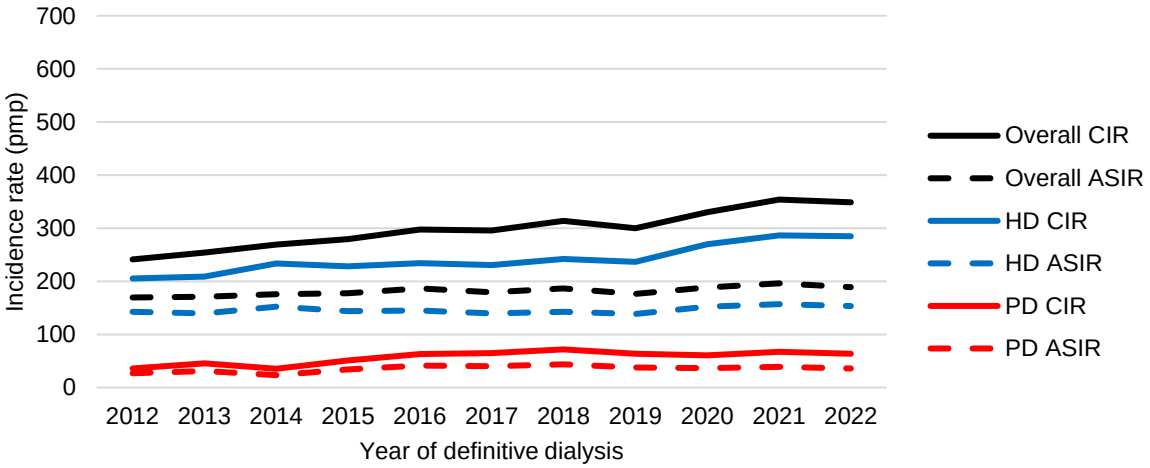
Table 5.4.5: Incidence number and rate (pmp) of definitive dialysis by modality

HD				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2012	784	85.1	205.4	142.8
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	1142	80.9	286.4	157.0
2022	1160	81.7	284.8	153.2
P for trend	-	-	<0.001	0.124

[19] 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**
2012	137	14.9	35.9	26.7
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	245	18.4	60.6	36.4
2021	269	19.1	67.5	39.2
2022	260	18.3	63.8	35.9
P for trend	-	-	0.003	0.040

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, followed by GN (Table 5.4.6). In 2022, 64.6% of the new definitive dialysis patients had DN, while 12.7% had GN. According to data collected by the USRDS, in 2020, Singapore had the highest incidence of treated CKD5[20] attributed to diabetes in the world, both in terms of rates and percentages[21].

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

[21] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/11-international-comparisons. Accessed 24 August 2023.

Table 5.4.6: Incidence number of definitive dialysis by etiology

Year of definitive dialysis	DN		GN		Others	
	Number	%	Number	%	Number	%
2012	609	66.1	144	15.6	168	18.2
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	904	67.7	164	12.3	267	20.0
2021	942	66.8	179	12.7	290	20.6
2022	917	64.6	181	12.7	322	22.7

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.

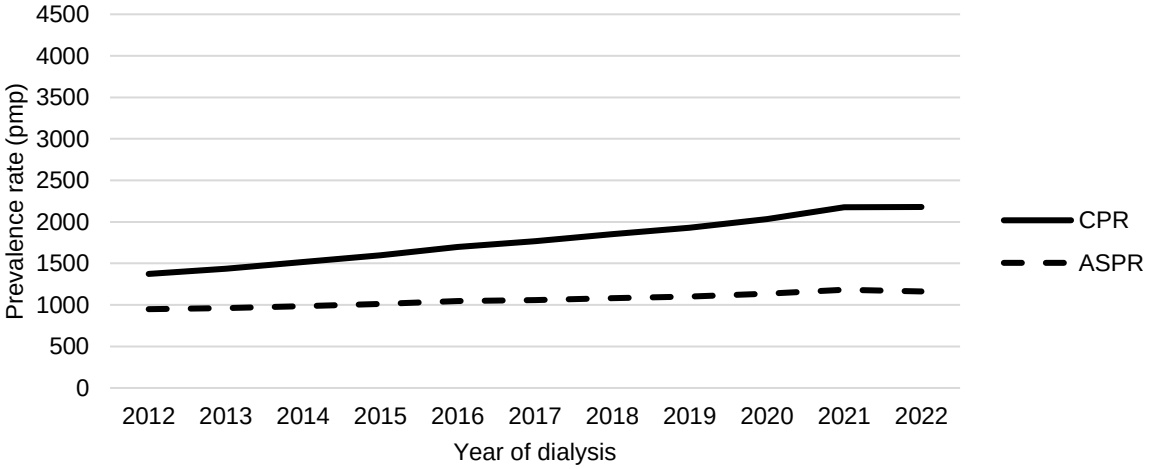
Like the incidence trends of definitive dialysis (Table 5.4.1 and Figure 5.4.1), the number of prevalent patients on definitive dialysis increased consistently since 2012 (Table 5.5.1 and Figure 5.5.1). Correspondingly, both the crude prevalence rate (CPR, $p<0.001$) and ASPR ($p<0.001$) increased significantly over the years. At the end of 2022, there were a total of 8,878 surviving dialysis patients, with CPR of 2,179.6 pmp and ASPR of 1,161.8 pmp. 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 suggests that in 2020, Singapore had the fifth highest prevalence of dialysis, as well as the fifth highest average yearly rate of change in dialysis prevalence from 2010 to 2020[22].

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

Year of dialysis	Number	CPR	ASPR
2012	5244	1373.6	949.0
2013	5521	1436.1	961.8
2014	5879	1518.8	986.9
2015	6231	1596.6	1012.2
2016	6673	1696.4	1048.4
2017	7007	1766.9	1058.8
2018	7406	1854.2	1081.6
2019	7765	1928.6	1101.1
2020	8220	2032.5	1133.6
2021	8671	2174.9	1182.8
2022	8878	2179.6	1161.8
P for trend	-	<0.001	<0.001

[22] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/11-international-comparisons. Accessed 24 August 2023.

Figure 5.5.1: Prevalence rate (pmp) of definitive dialysis



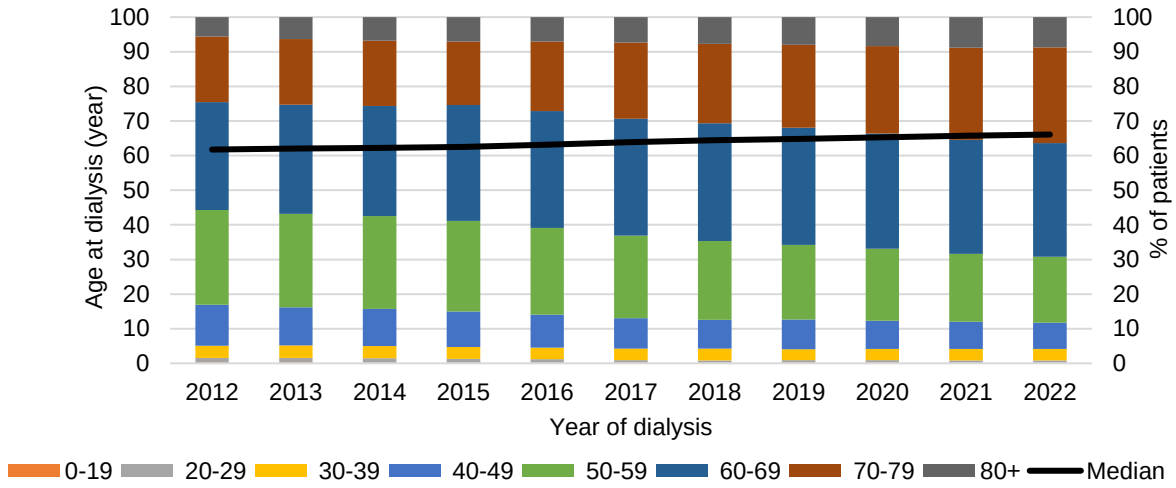
The age-specific prevalence rate of definitive dialysis increased for all age bands aged 20 years and above, with those aged 30-39 registering the largest percentage change (p<0.001) (Table 5.5.2). Nevertheless, older individuals comprised majority of prevalent dialysis patients. In 2022, almost 70% 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
2012	16	0.3	18.1	68	1.3	131.0	182	3.5	298.8	620	11.8	984.6
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	224	3.4	381.2	637	9.5	1036.4
2017	12	0.2	14.5	55	0.8	100.1	234	3.3	403.2	611	8.7	993.6
2018	13	0.2	15.9	51	0.7	93.2	249	3.4	425.6	621	8.4	1015.6
2019	14	0.2	17.2	59	0.8	109.8	241	3.1	405.5	668	8.6	1090.7
2020	19	0.2	23.6	55	0.7	103.5	266	3.2	445.3	674	8.2	1103.1
2021	18	0.2	23.0	54	0.6	104.7	290	3.3	491.3	679	7.8	1145.2
2022	13	0.1	16.5	60	0.7	116.9	293	3.3	481.8	673	7.6	1113.9
P for trend	-	-	0.086	-	-	0.017	-	-	<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
2012	1439	27.4	2471.7	1633	31.1	4763.7	991	18.9	5761.6	295	5.6	3801.5
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	22.8	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	2733	33.2	5316.9	2077	25.3	7957.9	689	8.4	5557.6
2021	1699	19.6	2908.3	2854	32.9	5509.6	2314	26.7	8497.9	763	8.8	5810.5
2022	1691	19.0	2852.5	2917	32.9	5442.8	2454	27.6	8336.3	777	8.8	5720.5
P for trend	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001

The median age among prevalent definitive dialysis patients increased from 61.8 years in 2012 to 66.1 years in 2022 (Figure 5.5.2a).

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



Similar to the trends observed for dialysis incidence, 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

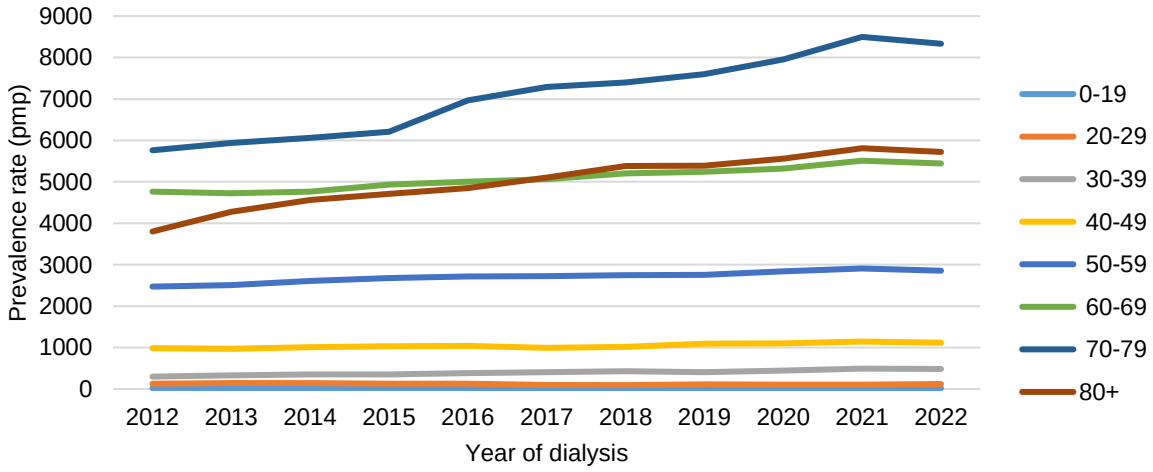
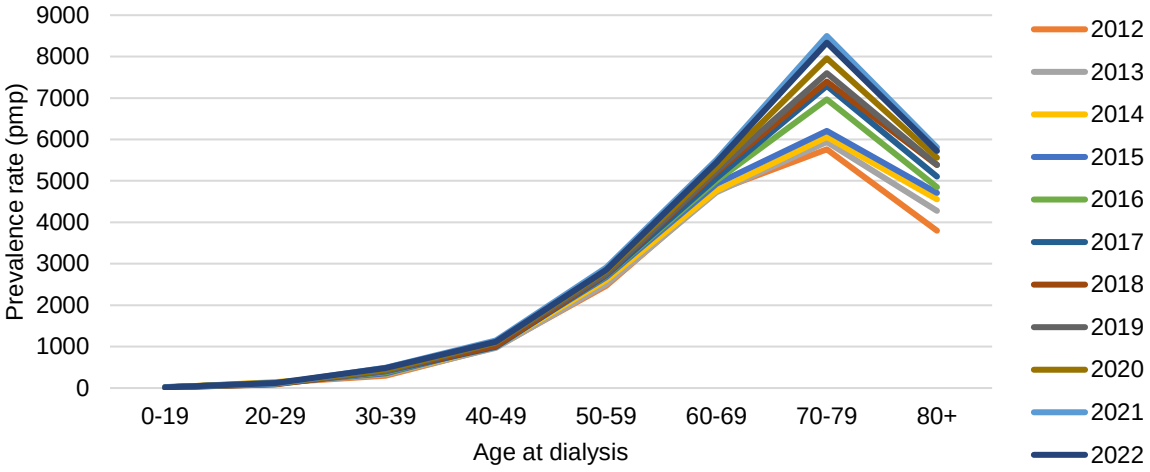


Figure 5.5.3: Age-specific prevalence rate (pmp) of definitive dialysis across age groups



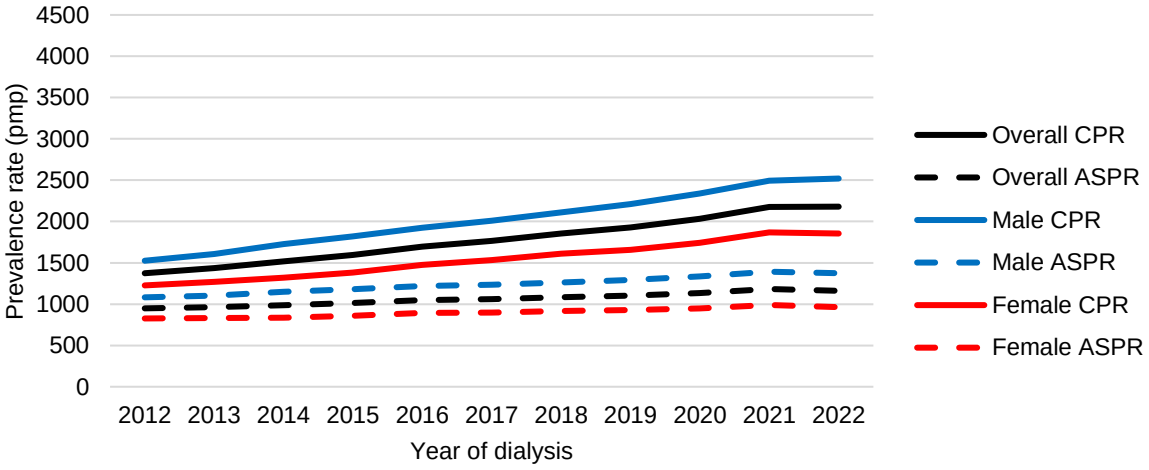
Akin to the trends for dialysis incidence, males comprised a higher percentage of prevalent dialysis patients, and the ASPRs of definitive dialysis were consistently higher among males than females across the years (Table 5.5.3 and Figure 5.5.4). In 2022, the ASPR was 1,375.5 pmp and 964.9 pmp for males 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**
2012	2867	54.7	1525.2	1082.1
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	55.7	1924.8	1217.8
2017	3906	55.7	2009.7	1234.4
2018	4127	55.7	2110.1	1261.3
2019	4355	56.1	2211.4	1290.8
2020	4622	56.2	2337.2	1335.8
2021	4872	56.2	2494.5	1392.2
2022	5015	56.5	2519.8	1375.5
P for trend	-	-	<0.001	<0.001

Female				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2012	2377	45.3	1226.6	826.6
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	2959	44.3	1476.5	893.3
2017	3101	44.3	1533.4	898.6
2018	3279	44.3	1608.6	917.6
2019	3410	43.9	1657.9	928.1
2020	3598	43.8	1741.0	947.7
2021	3799	43.8	1868.0	989.7
2022	3863	43.5	1854.5	964.9
P for trend	-	-	<0.001	<0.001

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

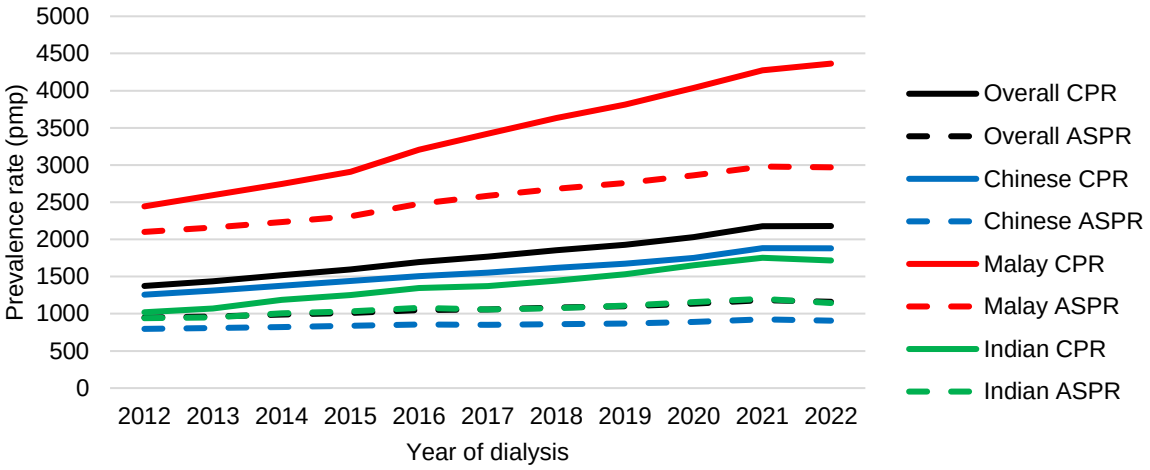


The ASPRs of definitive dialysis were consistently higher among Malays than Chinese and Indians across the years (Table 5.5.4 and Figure 5.5.5). In 2022, the ASPR was 906.4 pmp, 2,967.6 pmp and 1,144.9 pmp for Chinese, Malays and Indians respectively. While the ASPRs for all the three ethnic groups increased 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**
2012	3558	67.8	1256.5	796.5
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	64.5	1671.8	868.4
2020	5267	64.1	1751.7	888.3
2021	5571	64.2	1882.0	924.6
2022	5680	64.0	1881.4	906.4
P for trend	-	-	<0.001	<0.001
Malay				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2012	1245	23.7	2444.1	2100.6
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	25.3	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	2203	26.8	4038.5	2862.5
2021	2327	26.8	4274.0	2979.6
2022	2418	27.2	4363.8	2967.6
P for trend	-	-	<0.001	<0.001
Indian				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2012	358	6.8	1019.9	940.5
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	480	7.2	1345.0	1078.5
2017	493	7.0	1373.9	1059.6
2018	521	7.0	1445.1	1073.3
2019	556	7.2	1533.2	1107.8
2020	599	7.3	1653.4	1158.5
2021	622	7.2	1752.7	1200.4
2022	629	7.1	1716.7	1144.9
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[23]. Japan had the highest HD utilisation among prevalent dialysis patients in Asia, at 97%[24], with Hong Kong offering an interesting contrast – its "PD-first" approach meant that about two-thirds of prevalent CKD5 patients were on PD in 2020 – the highest PD uptake rate in the world among countries included in the USRDS data[25,26]. 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[27].

The ASPRs of definitive dialysis were consistently higher among HD than PD across the years (Table 5.5.5 and Figure 5.5.6). In 2022, the ASPR was 1,002.6 pmp and 159.2 pmp for HD and PD respectively. The ASPRs for both HD and PD increased significantly over the years ($p<0.001$).

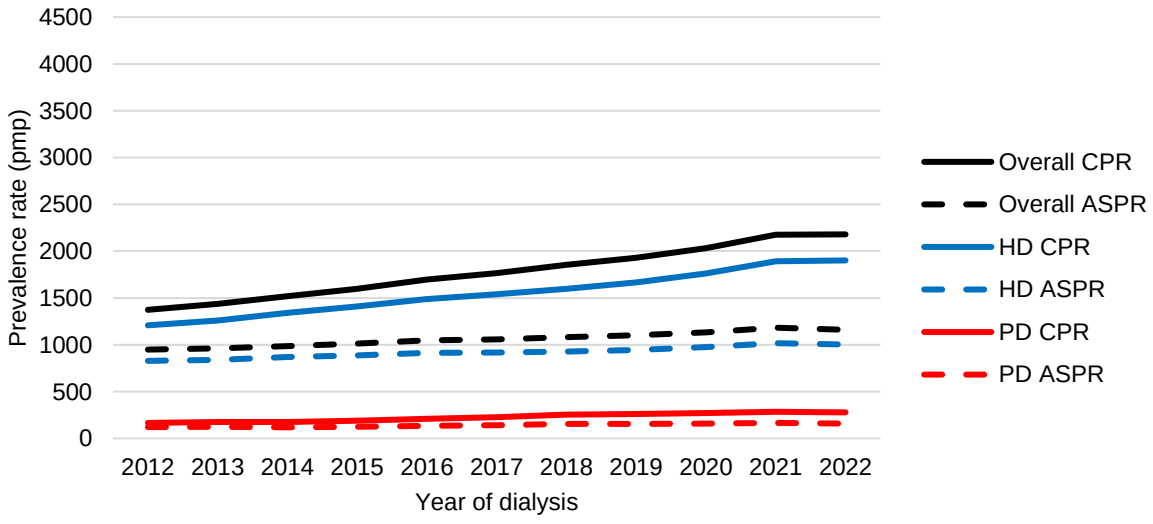
[23] Filipska A, Bohdan B, Wieczorek P and Hudz N. Chronic kidney disease and dialysis therapy: incidence and prevalence in the world. Pharmacia 68(2): 463–470.
[24] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/11-international-comparisons. Accessed 24 August 2023.
[25] Ibid.
[26] Li KT. et al. Peritoneal dialysis first policy in Hong Kong for 35 years: Global impact. Nephrology. 2022;27:787–794.
[27] 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**
2012	4612	87.9	1208.1	828.6
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	5850	87.7	1487.2	913.0
2017	6110	87.2	1540.7	917.7
2018	6388	86.3	1599.3	926.6
2019	6709	86.4	1666.3	944.7
2020	7128	86.7	1762.5	974.4
2021	7537	86.9	1890.5	1017.2
2022	7745	87.2	1901.4	1002.6
P for trend	-	-	<0.001	<0.001

PD				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2012	632	12.1	165.5	120.4
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	1092	13.3	270.0	159.2
2021	1134	13.1	284.4	165.6
2022	1133	12.8	278.2	159.2
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, a lower percentage 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 48.5% in 2012 to 56.0% in 2022 (Table 5.5.6). On the other hand, the proportion of prevalent definitive dialysis patients with GN dropped from 29.7% in 2012 to 21.6% in 2022. Similar to the situation in Singapore, diabetes is noted to be the most common cause of CKD5 worldwide[28].

Table 5.5.6: Prevalence number of definitive dialysis by etiology

Year of dialysis	DN		GN		Others	
	Number	%	Number	%	Number	%
2012	2544	48.5	1558	29.7	1142	21.8
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	1377	20.6
2017	3803	54.3	1747	24.9	1457	20.8
2018	4065	54.9	1776	24.0	1565	21.1
2019	4291	55.3	1808	23.3	1666	21.5
2020	4608	56.1	1848	22.5	1764	21.5
2021	4882	56.3	1911	22.0	1878	21.7
2022	4975	56.0	1922	21.6	1981	22.3

[28] 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.

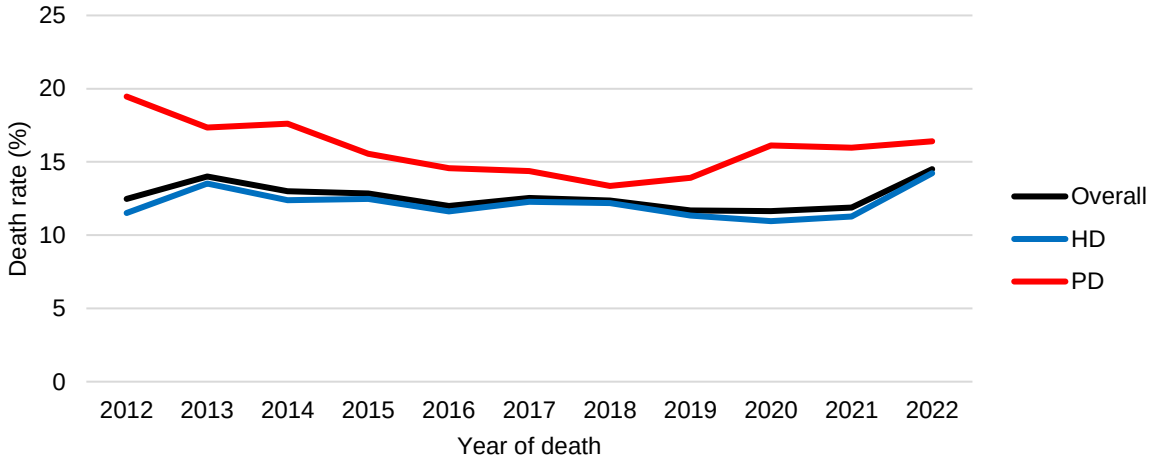
5.6 Mortality of definitive dialysis

In 2022, 14.5% of the patients on definitive dialysis died, compared to 12.5% a decade ago (Table 5.6.1 and Figure 5.6.1). Consistently, there were proportionally more deaths among PD patients than HD patients over the years, whereby the modality was based on the last modality that the dialysis patient received before death. The disparity in mortality between the two modalities narrowed 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	%
2012	654	12.5	531	11.5	123	19.5
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	16.0
2022	1288	14.5	1102	14.2	186	16.4

Figure 5.6.1: All-cause mortality by modality



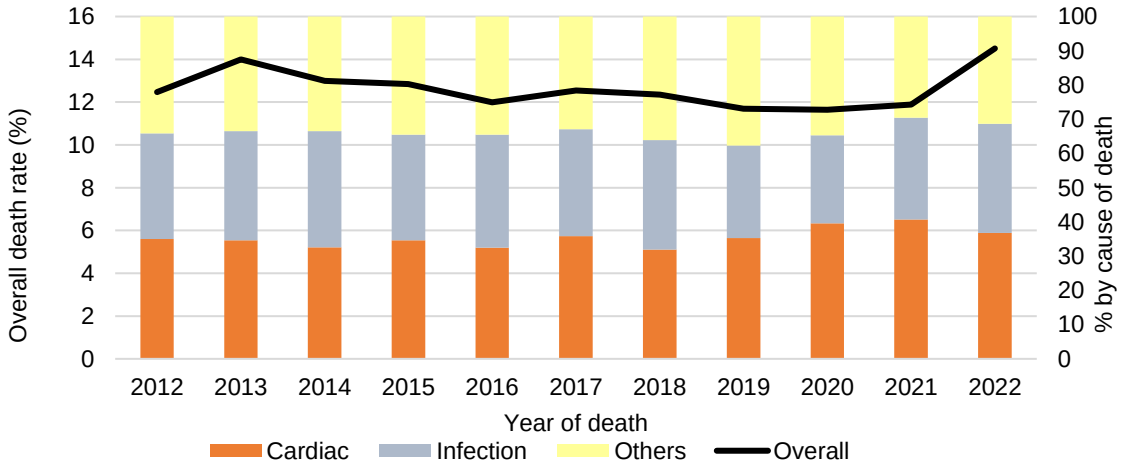
Deaths related to cardiac event and infection were the two most common causes of deaths among dialysis patients and each of them accounted for about a third of all deaths across the years (Table 5.6.2 and Figure 5.6.2). The burden of cardiovascular risk factors among dialysis patients is noted to be 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[29],[30].

Table 5.6.2: Mortality by cause of death

Year of death	Overall		Cardiac event		Infection		Others	
	Number	%*	Number	%^	Number	%^	Number	%^
2012	654	12.5	229	35.0	202	30.9	223	34.1
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	277	34.6	247	30.9	276	34.5
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	1288	14.5	474	36.8	411	31.9	403	31.3

*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



[29] Himmelfarb J, Vanholder R, Mehrotra R, and Tonelli M. The current and future landscape of dialysis. Nephrology. 2020;16.
[30] 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 2023, the date until which the death status of all patients were updated for this report). Median survival duration is indicated as “not reached (NR)” if more than half of the patients were alive as of 30 April 2023. 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 ($p=0.001$) were higher among PD patients. However, HD patients had higher proportions of 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	56.0	57.2	56.2
Sex (%)			
Male	57.4	50.5	56.0
Ethnicity (%)			
Chinese	65.6	72.1	67.0
Malay	25.0	20.0	23.9
Indian	7.7	6.2	7.4
Etiology (%)			
DN	62.7	62.5	62.7
Co-morbidities (%)			
Ischemic heart disease	46.4	45.0	46.1
Cerebrovascular disease	23.2	25.5	23.7
Peripheral vascular disease	15.0	12.7	14.5
Cancer	9.1	4.8	8.2

HD patients had significantly better survival than PD patients as indicated by their higher survival rates 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	90.2	90.7
5-year survival (%)	60.8	42.9	56.9
10-year survival (%)	32.1	20.3	29.6
Median survival (years)	6.6	4.2	6.0

Although 5- and 10-year survival were consistently better among HD than PD patients, their gap narrowed over the years as the survival of HD patients were similar throughout the years, while the survival of PD patients improved over the years (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[31].

Table 5.7.3: Survival of definitive dialysis by year and modality

	1999-2004			2005-2010		
	HD	**PD**	**Overall**	**HD**	**PD**	**Overall**
1-year survival (%)	90.7	85.4	89.0	89.4	88.5	89.2
5-year survival (%)	58.5	32.5	49.7	59.5	40.0	55.8
10-year survival (%)	33.2	15.0	27.0	30.8	18.8	28.5
Median survival (years)	6.5	3.4	5.0	6.4	3.9	5.8
	2011-2016			**2017-2022**		
	HD	**PD**	**Overall**	**HD**	**PD**	**Overall**
1-year survival (%)	90.6	91.7	90.8	91.9	94.0	92.3
5-year survival (%)	60.9	49.6	59.0	NA	NA	NA
10-year survival (%)	NA	NA	NA	NA	NA	NA
Median survival (years)	6.6	5.0	6.3	NR	NR	NR

Younger patients aged below 60 years had significantly better survival than older patients aged 60 years and above regardless of modality (p<0.001) (Table 5.7.4).

[31] 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 (%)	93.7	93.6	93.7	88.7	87.6	88.4
5-year survival (%)	71.9	59.2	69.3	51.7	30.9	47.0
10-year survival (%)	46.2	35.8	44.1	19.7	8.5	17.2
Median survival (years)	9.2	6.5	8.7	5.2	3.4	4.6

Female HD patients had significantly better survival than male HD patients (p=0.002). However, there were no significant differences in survival between the two sexes for PD (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	90.3	90.5	91.3	90.0	91.0
5-year survival (%)	59.9	43.8	56.7	62.0	42.0	57.1
10-year survival (%)	31.3	19.1	29.0	33.2	21.4	30.3
Median survival (years)	6.5	4.4	6.0	6.7	4.1	6.0

Malay HD patients had significantly better survival than Chinese and Indian HD patients (p<0.001) (Table 5.7.6). However, survival among PD patients was fairly similar across the three ethnic groups.

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 (%)	90.9	90.3	90.8	91.2	89.8	91.0	90.1	89.5	90.0
5-year survival (%)	59.8	43.0	55.9	63.8	41.4	59.7	59.0	44.0	56.3
10-year survival (%)	31.0	19.7	28.4	36.2	21.8	33.5	28.1	19.4	26.6
Median survival (years)	6.4	4.3	5.8	7.2	4.1	6.5	6.0	4.0	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[32].

[32] 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 5.7.7: Survival of definitive dialysis by etiology and modality

	Non-DN			DN		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	92.4	93.9	92.7	90.0	87.9	89.5
5-year survival (%)	71.7	64.4	70.1	54.4	30.6	49.2
10-year survival (%)	49.0	39.2	47.0	21.7	9.4	19.1
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).

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 (%)	93.0	93.2	93.1	88.6	86.7	88.2
5-year survival (%)	70.2	55.6	67.0	50.7	29.2	46.0
10-year survival (%)	43.2	31.0	40.6	19.9	9.4	17.6
Median survival (years)	8.6	5.7	8.0	5.1	3.3	4.5

Patients without cerebrovascular disease (CVD) had significantly better survival than those with CVD regardless of modality (p<0.001) (Table 5.7.9).

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 (%)	92.0	91.8	92.0	87.5	85.9	87.1
5-year survival (%)	64.7	48.8	61.3	49.2	28.0	44.1
10-year survival (%)	36.0	24.2	33.6	19.2	10.2	17.1
Median survival (years)	7.2	4.8	6.7	4.9	3.1	4.3

Patients without peripheral vascular disease (PVD) had significantly better survival than those with PVD regardless of modality (p<0.001) (Table 5.7.10).

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	91.6	91.9	85.8	82.2	85.1
5-year survival (%)	64.2	46.7	60.4	44.3	22.8	40.2
10-year survival (%)	35.5	23.0	32.8	14.6	4.6	12.7
Median survival (years)	7.2	4.6	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).

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	91.8	91.9	84.0	89.6	84.6
5-year survival (%)	63.2	46.1	59.5	46.7	36.4	45.6
10-year survival (%)	33.8	22.1	31.3	20.1	11.3	19.1
Median survival (years)	6.9	4.6	6.4	4.6	3.5	4.5

PD, older age, 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).

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 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[33]. 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[34,35].

[33] 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.
[34] 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.
[35] Ng JH, Woo KT and Tan EK. Survival outcome of haemodialysis and peritoneal dialysis. Ann Acad Med Singap 2022;51:132-3

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	1.50	1.82-1.97	
Age group			
<60 years	1.00	Reference	<0.001
⩾60 years	1.89	1.82-1.97	
Sex			
Male	1.00	Reference	0.238
Female	0.98	0.94-1.01	
Ethnicity			
Chinese	1.00	Reference	
Malay	0.91	0.87-0.95	<0.001
Indian	0.98	0.91-1.05	0.491
Etiology			
Non-DN	1.00	Reference	<0.001
DN	1.71	1.64-1.78	
IHD			
No	1.00	Reference	<0.001
Yes	1.47	1.42-1.53	
CVD			
No	1.00	Reference	<0.001
Yes	1.32	1.26-1.37	
PVD			
No	1.00	Reference	<0.001
Yes	1.50	1.42-1.57	
Cancer			
No	1.00	Reference	<0.001
Yes	1.45	1.36-1.55	

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[36,37,38,39] 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[40].

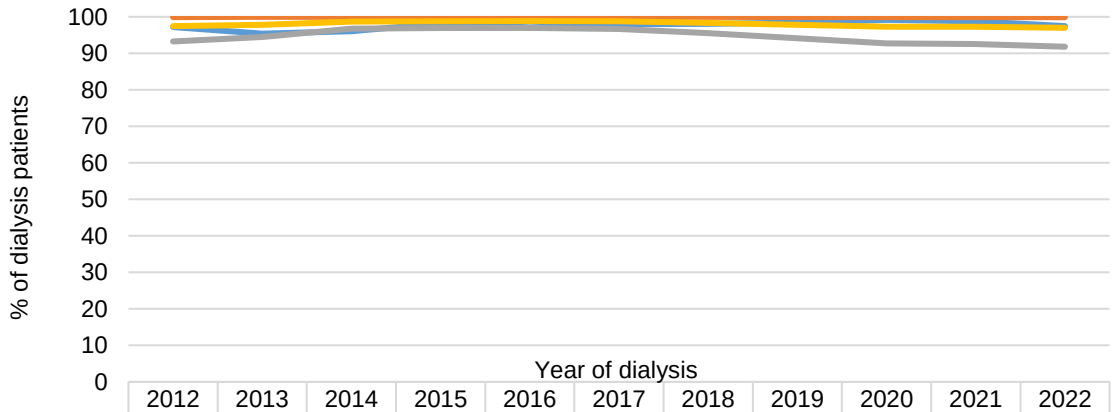
Most prevalent HD patients were dialysed in centres run by the VWOs, followed by the private sector, then the public sector. In 2022, the proportions of HD patients under the care of the VWOs, private sector and public sector were 62.8%, 35.2% and 2.0% respectively (Table 5.1.2). Compared to the VWO and private sector in the past decade, the number of HD patients from the public sector was smaller, resulting in less stable trends.

[36] National Kidney Foundation: K/DOQI clinical practice guidelines for hemodialysis adequacy, 2000. American Journal of Kidney Disease. 2001; 37 (suppl 1): S7-S64.
[37] 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.
[38] Mimura I, Tanaka T, Nangaku M. How the target hemoglobin of renal anemia should be? Nephron. 2015; 131: 202-209.
[39] NKF KDOQI Guidelines. National Kidney Foundation, New York. http://kidneyfoundation.cachefly.net/professionals/KDOQI/guidelines_bone/guidestate.htm Accessed on 1 Mar 2021.
[40] 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 2022, 90.9% 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 2022, 97.5%, 99.9% and 91.8% of the patients from the public, VWOs and private sector underwent thrice weekly dialysis respectively.

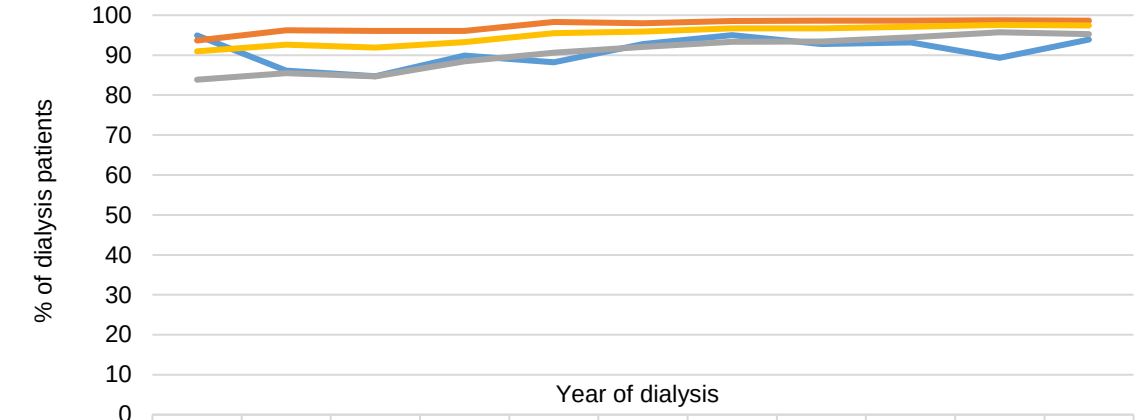
Figure 5.8.1a: Proportion of HD patients with thrice weekly dialysis



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	97.2	95.4	96.1	98.3	97.1	98.0	98.1	98.5	99.2	98.8	97.5
VWO	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9	99.9	99.9
Private	93.3	94.5	96.8	96.9	97.0	96.7	95.6	94.2	92.7	92.6	91.8
Overall	97.5	97.8	98.7	98.8	98.8	98.8	98.4	97.8	97.3	97.3	97.0

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 (Figure 5.8.1b). However, the private sector was catching up, with proportion rising from 83.8% in 2012 to 95.2% in 2022. In 2022, 93.9% and 98.6% of the patients from the public sector and VWOs met the criteria respectively.

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

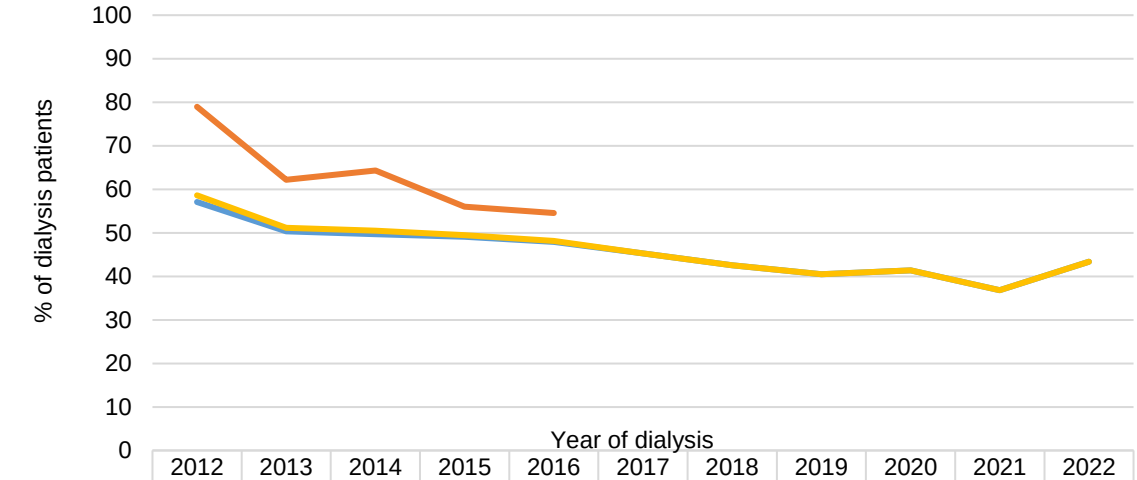


	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	94.9	86.2	84.7	89.9	88.2	92.8	95.0	92.8	93.2	89.3	93.9
VWO	93.7	96.2	96.0	96.0	98.3	98.0	98.6	98.7	98.6	98.7	98.6
Private	83.8	85.5	84.7	88.4	90.6	92.1	93.3	93.4	94.4	95.7	95.2
Overall	90.9	92.6	91.9	93.3	95.5	95.9	96.7	96.7	97.1	97.6	97.4

The proportion of prevalent PD patients who met the adequate management of urea criteria of Kt/V >=2.0% dropped from 58.6% in 2012 to 43.3% in 2022 (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[41].

[41] 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.

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

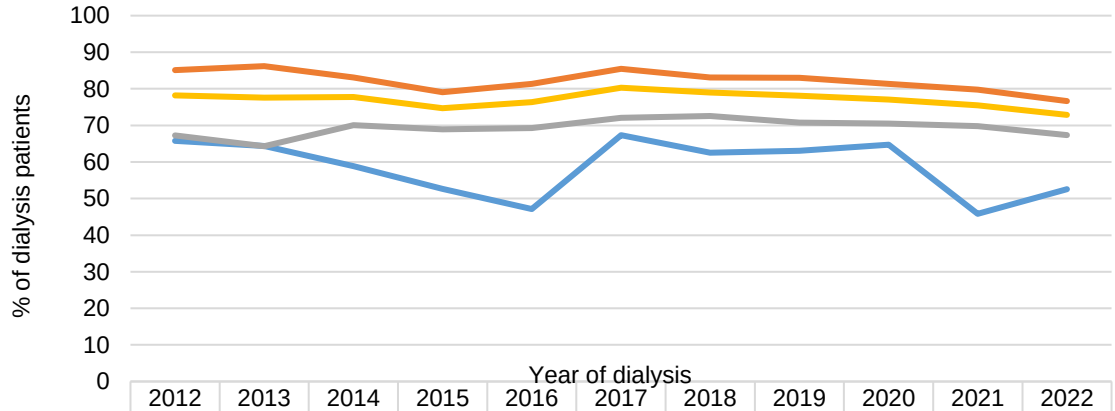


	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	57.1	50.3	49.7	49.1	47.9	45.2	42.6	40.5	41.4	36.8	43.3
VWO	78.9	62.2	64.3	56.0	54.5						
Overall	58.6	51.1	50.5	49.4	48.2	45.2	42.6	40.5	41.4	36.8	43.3

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 2022, 52.5%, 76.7% and 67.3% of the patients from the public, VWOs and private sector fulfilled the criteria respectively.

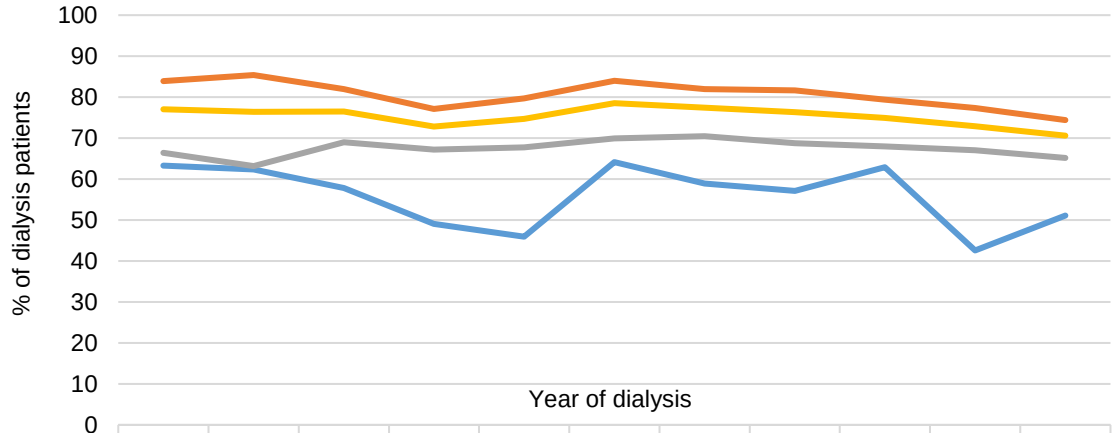
Similar trends were observed after stratification by ESA, a drug that stimulates the production of erythropoietin, a hormone produced primarily by the kidneys and plays a key role in the production of red blood cells (Figures 5.8.3b and 5.8.3c). In addition, across all sectors, the proportion of prevalent HD patients who fulfilled the adequate management of anaemia criteria was consistently higher among those who were not taking ESA than those on ESA (Figure 5.8.3b and 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)



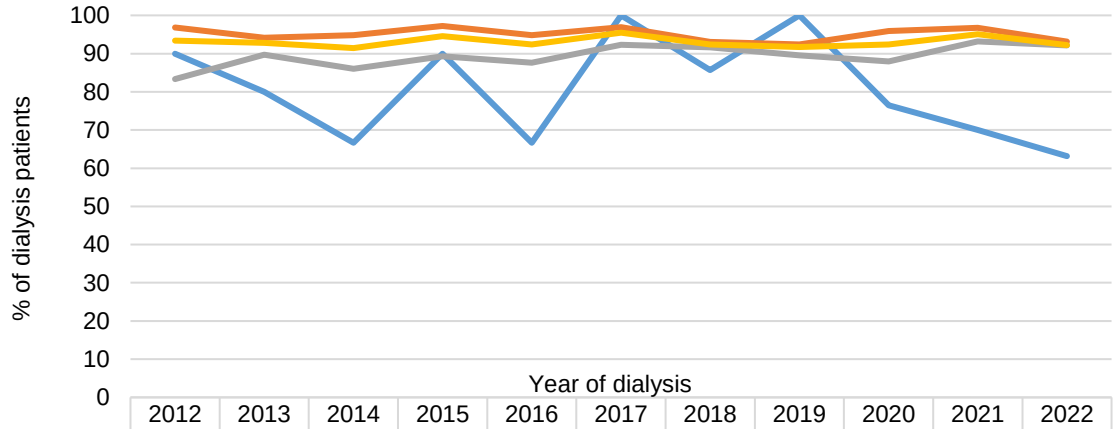
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	65.7	64.4	58.8	52.6	47.1	67.3	62.5	63.1	64.8	45.8	52.5
VWO	85.1	86.2	83.1	79.1	81.3	85.4	83.1	83.0	81.3	79.8	76.7
Private	67.3	64.3	70.1	68.9	69.3	72.1	72.6	70.8	70.5	69.8	67.3
Overall	78.2	77.6	77.7	74.7	76.4	80.3	79.0	78.1	77.0	75.5	72.9

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



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	63.3	62.3	57.8	49.0	45.9	64.1	58.9	57.1	62.9	42.6	51.1
VWO	83.9	85.4	81.9	77.1	79.7	84.0	81.9	81.7	79.4	77.4	74.4
Private	66.4	63.2	69.0	67.2	67.7	69.9	70.5	68.8	67.9	67.0	65.2
Overall	77.0	76.4	76.5	72.8	74.7	78.5	77.4	76.3	74.9	72.9	70.6

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

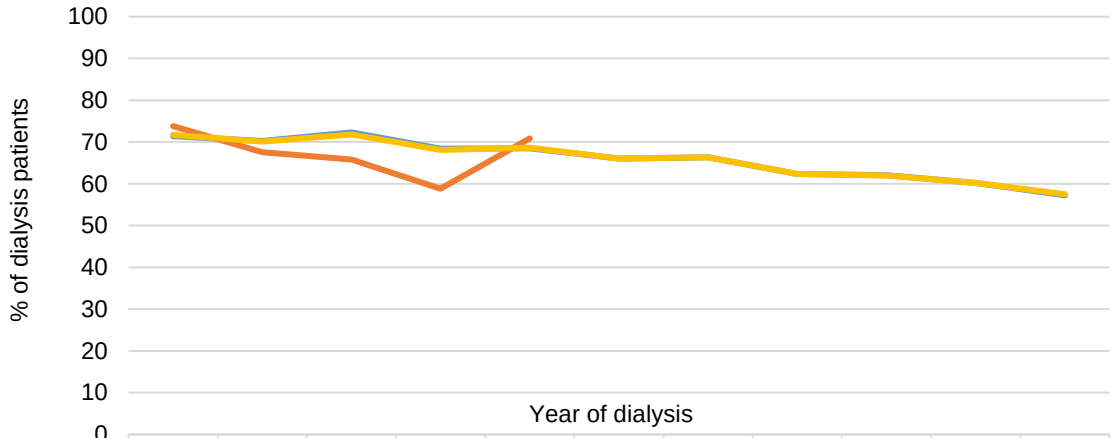


	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	90.0	80.0	66.7	90.0	66.7	100.0	85.7	100.0	76.5	70.0	63.2
VWO	96.9	94.2	94.8	97.2	94.8	96.9	93.0	92.4	95.9	96.8	93.2
Private	83.3	89.7	86.1	89.3	87.7	92.3	91.6	89.5	87.9	93.2	92.2
Overall	93.4	92.8	91.4	94.5	92.4	95.5	92.4	91.7	92.4	95.1	92.2

The proportion of prevalent PD patients who fulfilled the adequate management of anaemia criteria of hb >=10 g/dL dropped from 71.7% in 2012 to 57.5% in 2022 (Figure 5.8.4a).

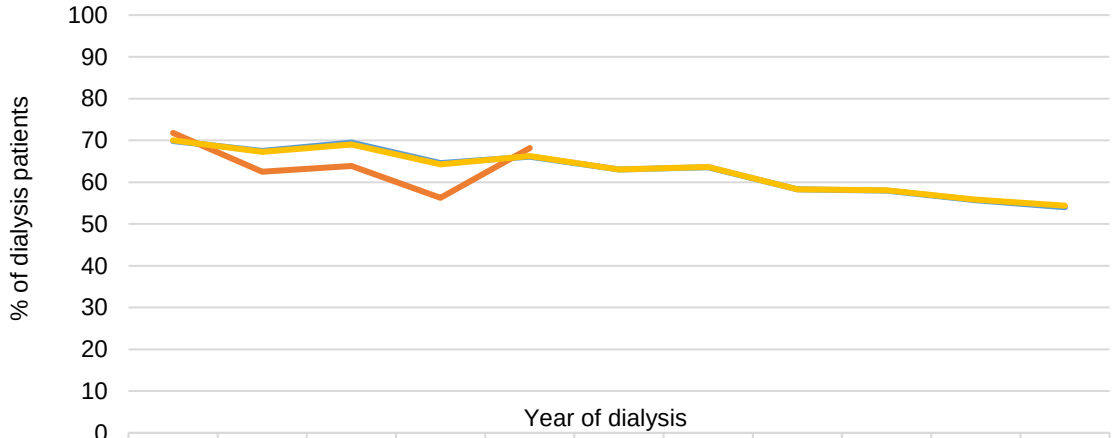
Similar decreasing trend was observed among PD patients taking ESA (Figure 5.8.4b), but the trend since 2017 was stable among those not on ESA (Figure 5.8.4c). Like HD patients, the proportion of PD patients fulfilling the criteria was consistently higher among those who were not taking ESA than those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

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



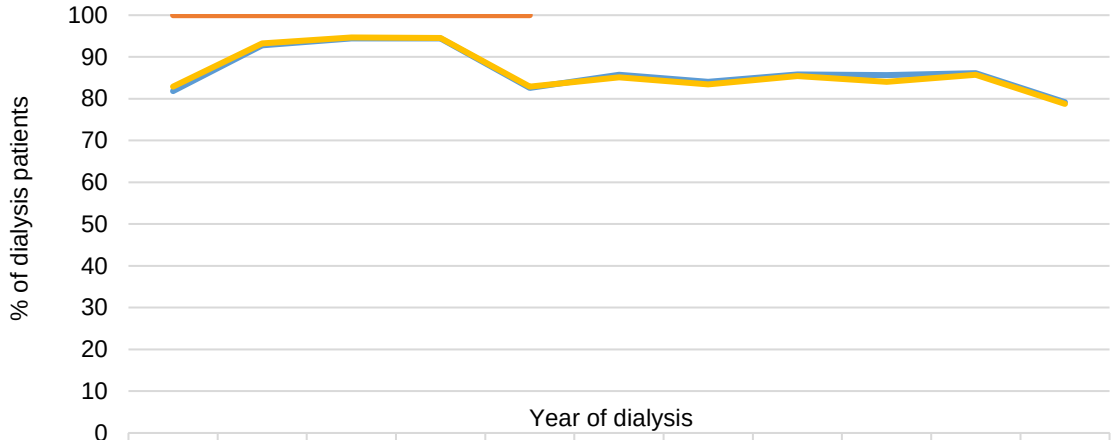
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	71.4	70.2	72.3	68.4	68.5	66.1	66.3	62.4	62.0	60.2	57.3
VWO	73.8	67.6	65.8	58.8	70.8						
Overall	71.7	70.1	71.8	68.1	68.6	66.0	66.3	62.4	62.0	60.2	57.5

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



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	69.8	67.5	69.5	64.6	66.1	63.0	63.5	58.3	58.0	55.7	54.0
VWO	71.8	62.5	63.9	56.3	68.2						
Overall	70.0	67.3	69.0	64.3	66.2	63.0	63.6	58.3	58.1	55.8	54.4

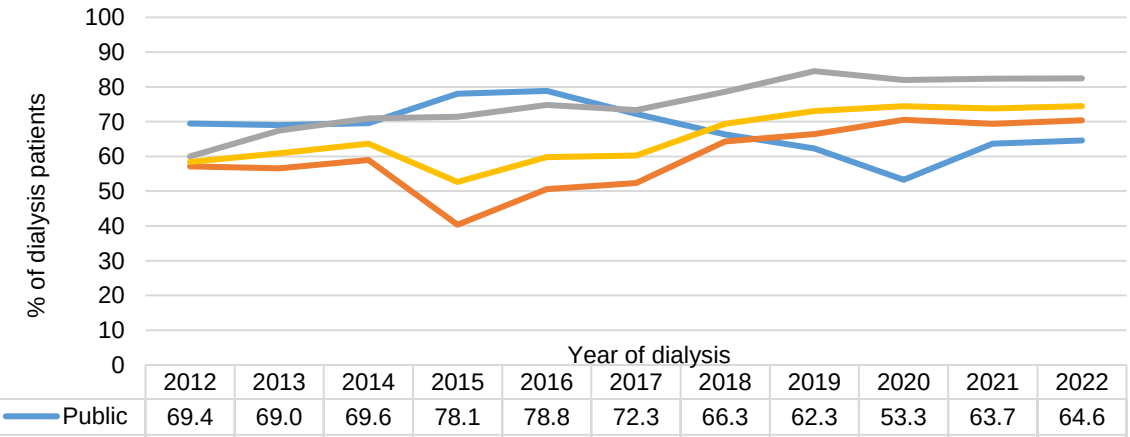
Figure 5.8.4c: Proportion of PD patients not on ESA with adequate management of anaemia (hb >=10 g/dL)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	81.8	92.8	94.4	94.4	82.6	85.7	84.1	85.8	85.6	86.1	79.2
VWO	100.0	100.0	100.0	100.0	100.0						
Overall	82.9	93.2	94.7	94.6	82.9	85.1	83.4	85.4	84.1	85.7	78.8

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 2022, 64.6%, 70.4% and 82.4% of the patients from the public sector, VWOs and private sector passed the criteria respectively.

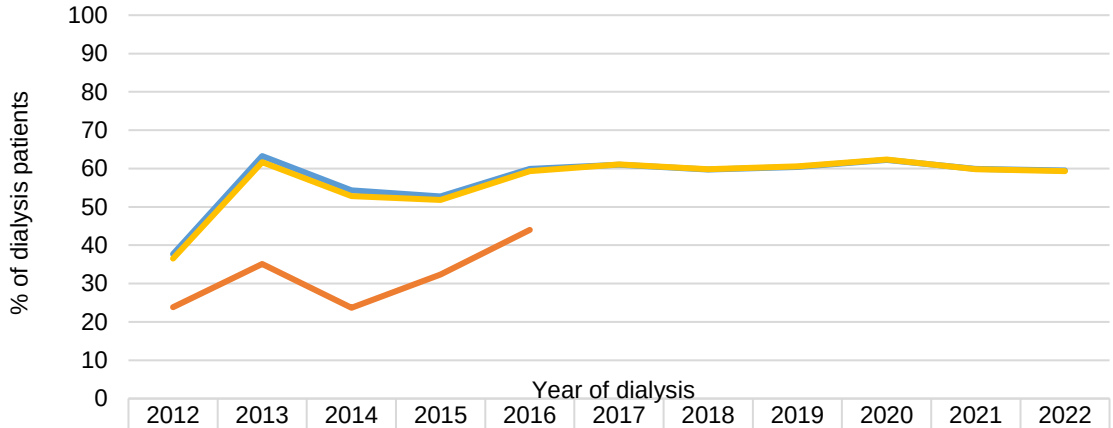
Figure 5.8.5: Proportion of HD patients with adequate management of mineral and bone disease (corrected serum Ca <2.37 mmol/L)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	69.4	69.0	69.6	78.1	78.8	72.3	66.3	62.3	53.3	63.7	64.6
VWO	57.2	56.6	59.0	40.3	50.5	52.4	64.3	66.4	70.5	69.4	70.4
Private	60.0	67.4	71.0	71.4	74.8	73.3	78.6	84.5	82.0	82.3	82.4
Overall	58.5	60.9	63.7	52.7	59.8	60.3	69.4	73.0	74.4	73.8	74.5

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 increased from 36.5% in 2012 to 59.4% in 2022 (Figure 5.8.6).

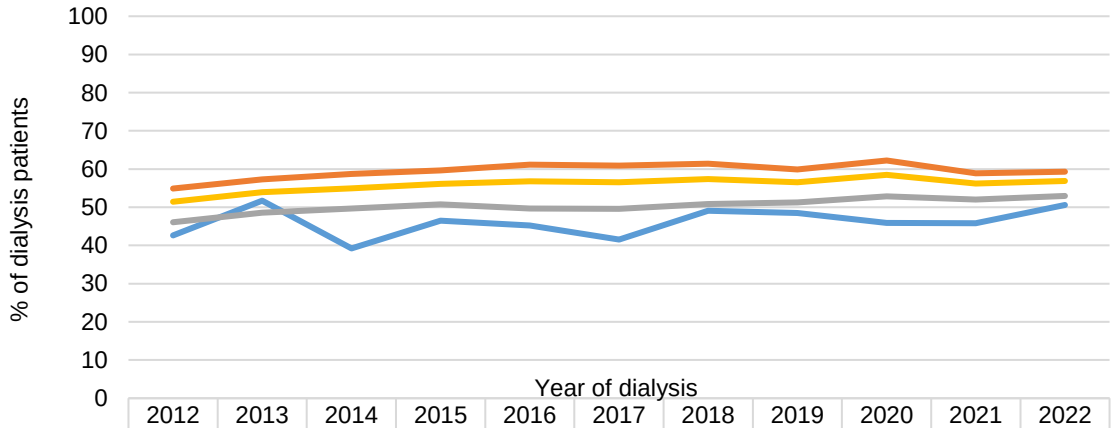
Figure 5.8.6: Proportion of PD patients with adequate management of mineral and bone disease (corrected serum Ca <2.37 mmol/L)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	37.7	63.3	54.3	52.7	59.9	61.0	59.8	60.4	62.2	59.9	59.5
VWO	23.8	35.1	23.7	32.3	44.0						
Overall	36.5	61.7	52.8	51.8	59.3	61.0	59.8	60.6	62.3	59.9	59.4

The proportion of prevalent HD 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 was consistently higher for the VWOs than the public and private sectors across the years (Figure 5.8.7). In 2022, 50.6%, 59.3% and 53.0% of the patients from the public sector, VWOs and private sector passed the criteria respectively.

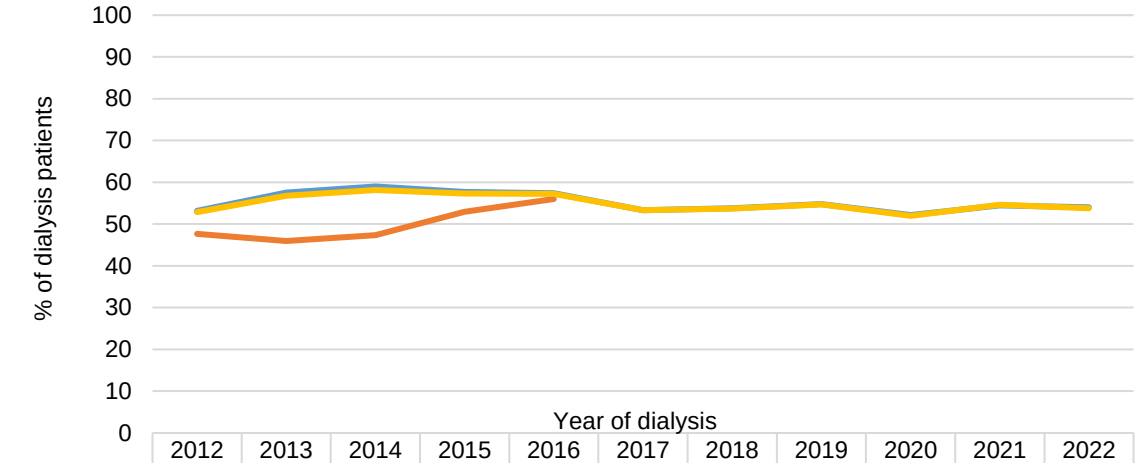
Figure 5.8.7: Proportion of HD patients with adequate management of mineral and bone disease (serum PO_4 >1.13 mmol/L and <1.78 mmol/L)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	42.6	51.7	39.2	46.5	45.2	41.6	49.0	48.5	45.9	45.8	50.6
VWO	54.9	57.3	58.7	59.7	61.2	60.9	61.4	59.9	62.2	58.9	59.3
Private	46.1	48.6	49.7	50.8	49.7	49.6	50.8	51.3	52.8	52.0	53.0
Overall	51.4	53.9	54.9	56.1	56.8	56.5	57.4	56.5	58.5	56.2	56.9

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 2012 to 2022 (Figure 5.8.8).

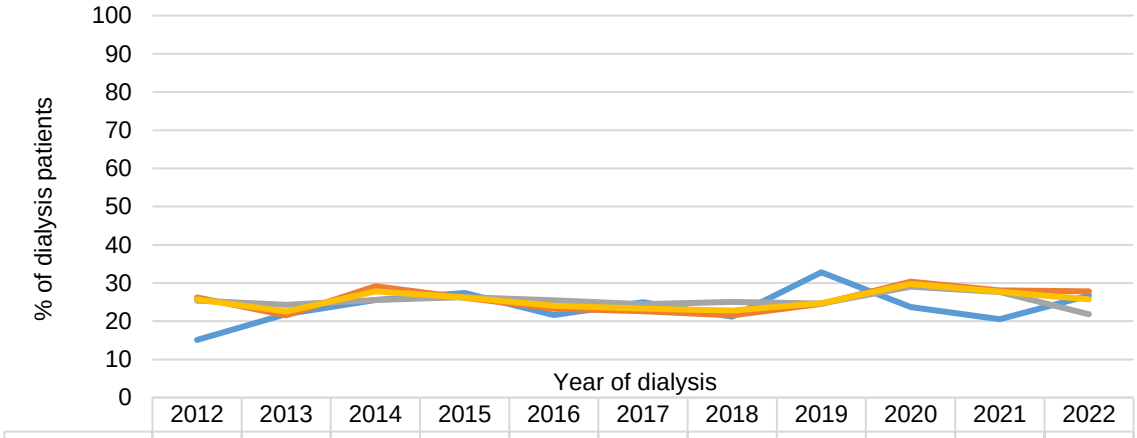
Figure 5.8.8: Proportion of PD patients with adequate management of mineral and bone disease (serum PO_4 >1.13 mmol/L and <1.78 mmol/L)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	53.2	57.6	59.0	57.7	57.4	53.4	53.8	54.8	52.2	54.5	54.0
VWO	47.6	46.0	47.4	52.9	56.0						
Overall	52.9	56.8	58.2	57.3	57.3	53.3	53.7	54.7	52.0	54.6	53.8

The proportion of prevalent HD patients who passed the adequate management of mineral and bone disease criteria of 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 2022, 26.8%, 27.8% and 21.8% of the patients from the public sector, VWOs and private sector passed the criteria respectively.

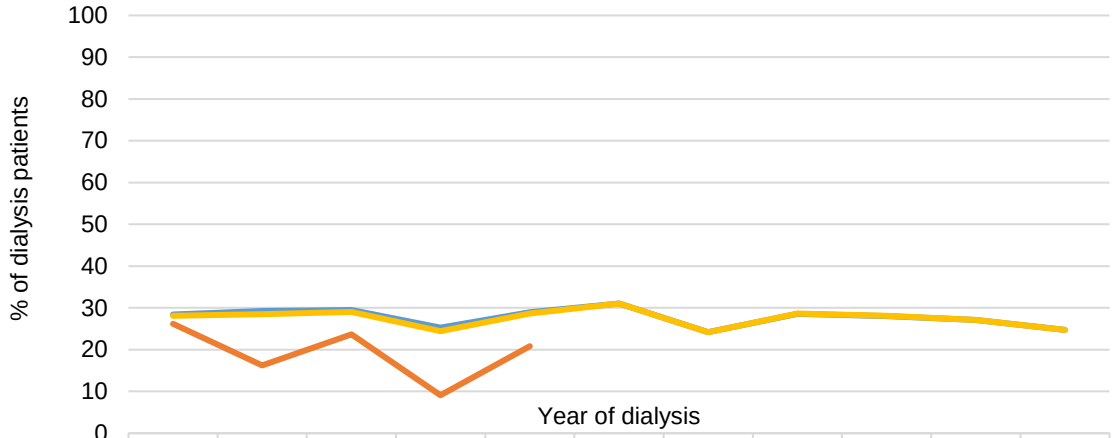
Figure 5.8.9: Proportion of HD patients with adequate management of mineral and bone disease (serum iPTH >16.3 pmol/L and <33.0 pmol/L)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	15.1	21.8	25.5	27.4	21.6	25.0	21.2	32.8	23.7	20.5	26.8
VWO	26.2	21.5	29.2	26.1	23.3	22.6	21.5	24.5	30.3	28.0	27.8
Private	25.4	24.3	25.6	26.3	25.5	24.4	25.1	24.6	29.0	27.6	21.8
Overall	25.7	22.5	27.8	26.2	24.0	23.3	22.8	24.7	29.8	27.7	25.7

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% in 2012 to 2022 (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)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Public	28.4	29.2	29.5	25.3	29.0	31.0	24.2	28.6	28.1	27.1	24.8
VWO	26.2	16.2	23.7	9.1	20.8						
Overall	28.1	28.5	29.1	24.4	28.7	31.0	24.2	28.7	28.1	27.1	24.8

5.9 Incidence of kidney transplant

The incidence rate of kidney transplant in each year was calculated by taking the number of 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.

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 and 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 2022, 76 patients received kidney transplant; the CIR was 18.7 pmp and ASIR was 15.1 pmp.

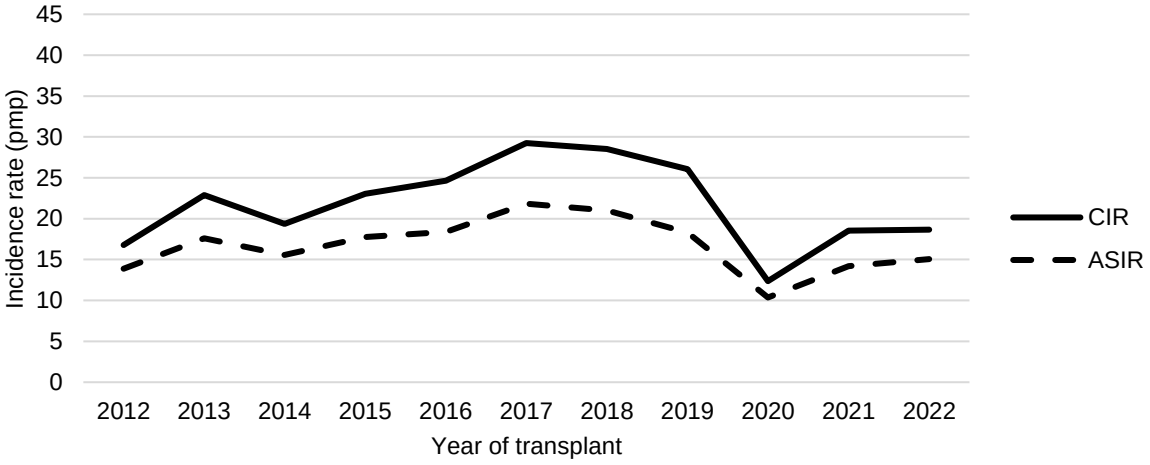
Based on data collected from the USRDS, Asian countries had lower rates of kidney transplant among dialysis patients. In contrast, European countries had the highest rates of kidney transplantation among dialysis patients[42].

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

Year of transplant	Number	CIR	ASIR
2012	64	16.8	13.9
2013	88	22.9	17.6
2014	75	19.4	15.6
2015	90	23.1	17.8
2016	97	24.7	18.4
2017	116	29.3	21.8
2018	114	28.5	21.0
2019	105	26.1	18.3
2020	50	12.4	10.4
2021	74	18.6	14.2
2022	76	18.7	15.1
P for trend	-	0.665	0.534

[42] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/11-international-comparisons. Accessed 24 August 2023.

Figure 5.9.1: Incidence rate (pmp) of kidney transplant



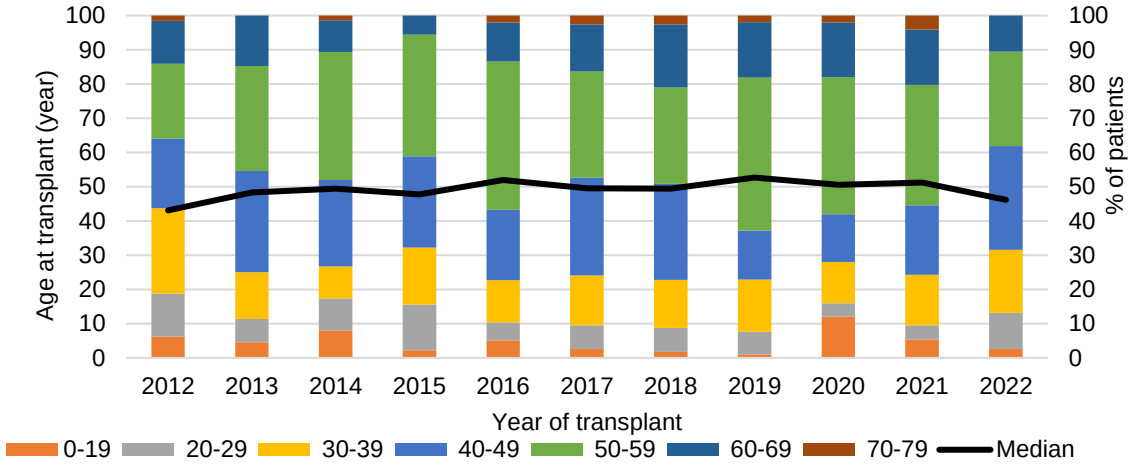
The age-specific incidence rate of kidney transplant fluctuated for all age groups due to the small number of transplants done each year, and there were no significant changes in the age-specific incidence of kidney transplant across all age groups (Table 5.9.2).

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
2012	4	6.3	4.5	8	12.5	15.4	16	25.0	26.3	13	20.3	20.6
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	13.3	22.4	15	16.7	25.4	24	26.7	38.7
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	6.9	14.6	17	14.7	29.3	33	28.4	53.7
2018	2	1.8	2.4	8	7.0	14.6	16	14.0	27.3	32	28.1	52.3
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
P for trend	-	-	0.460	-	-	0.195	-	-	0.796	-	-	0.657
Year of transplant	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2012	14	21.9	24.0	8	12.5	23.3	1	1.6	5.8	0	0.0	0.0
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	35.6	52.4	5	5.6	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	31.0	58.6	16	13.8	34.3	3	2.6	14.2	0	0.0	0.0
2018	32	28.1	52.2	21	18.4	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
P for trend	-	-	0.720	-	-	0.732	-	-	0.630	-	-	-

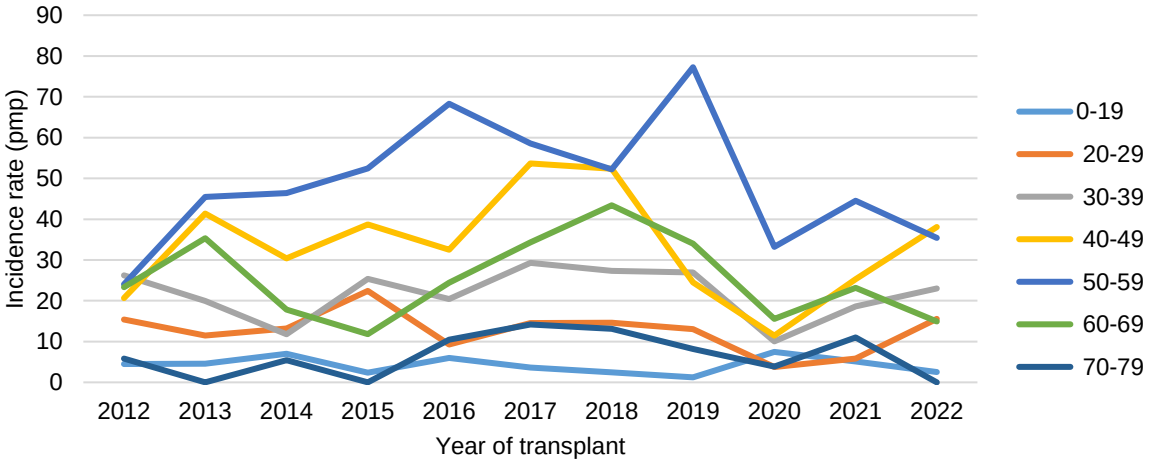
The median age at kidney transplant ranged between 43.1 and 52.7 years in the past decade, and the majority of transplant patients each year were aged between 40-59 years (Figure 5.9.2a).

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



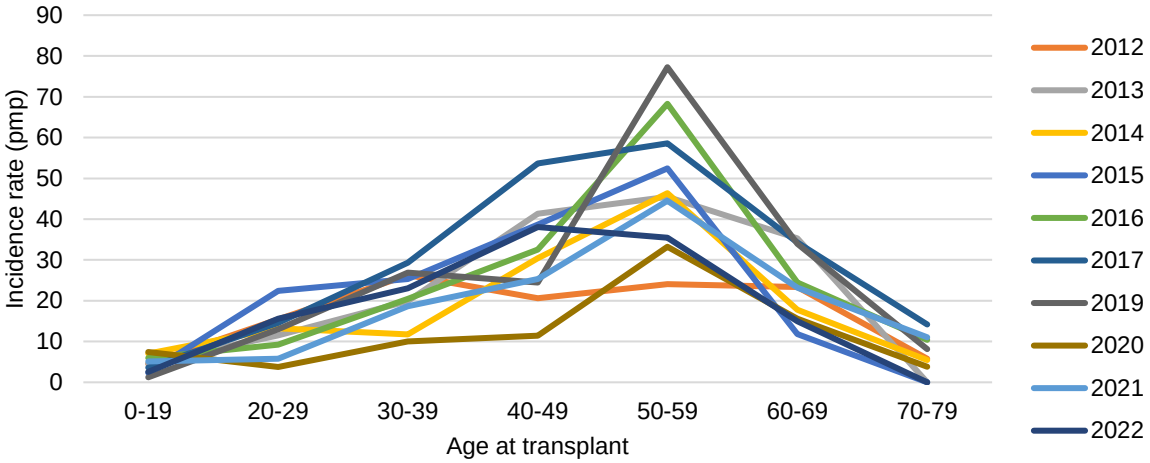
The age-specific incidence rate of kidney transplants was highest for those aged 50 to 59 years (Figure 5.9.2b).

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



The age-specific incidence rate of kidney transplant peaked at age 50-59 years for most of the years (Figure 5.9.3).

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



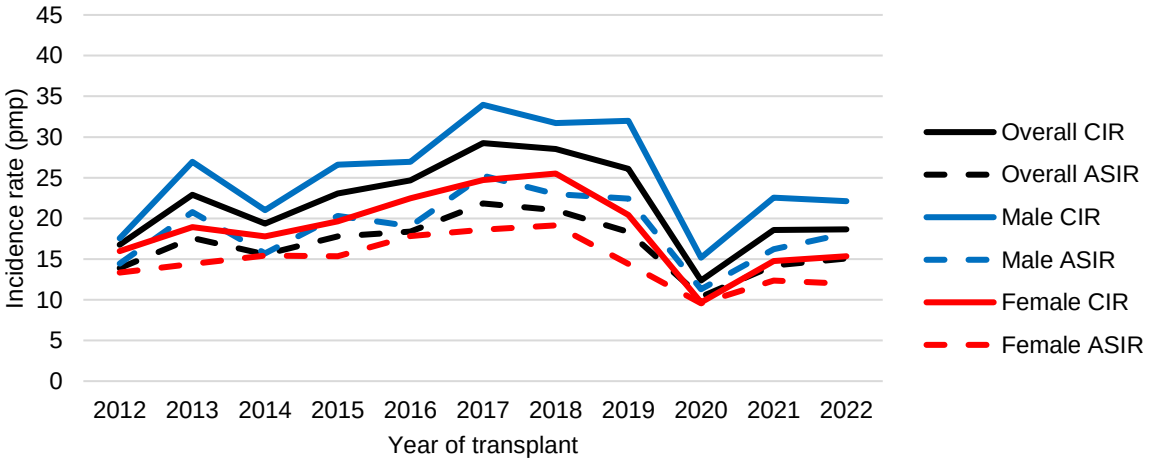
As with the trends of dialysis incidence, males comprised a higher percentage of kidney transplant patients every year, and the ASIRs of kidney transplant were generally higher among males than females across the years (Table 5.9.3 and Figure 5.9.4). In 2022, the ASIR was 18.2 pmp and 12.0 pmp for males and females respectively. The ASIRs for both sexes fluctuated over the years due to the small number of transplants done each year.

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

Male				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2012	33	51.6	17.6	14.5
2013	51	58.0	27.0	20.8
2014	40	53.3	21.0	15.7
2015	51	56.7	26.6	20.3
2016	52	53.6	26.9	19.0
2017	66	56.9	34.0	25.2
2018	62	54.4	31.7	23.0
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
P for trend	-	-	0.993	0.862

Female				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2012	31	48.4	16.0	13.3
2013	37	42.0	18.9	14.4
2014	35	46.7	17.8	15.4
2015	39	43.3	19.6	15.3
2016	45	46.4	22.5	17.8
2017	50	43.1	24.7	18.6
2018	52	45.6	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
P for trend	-	-	0.361	0.252

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

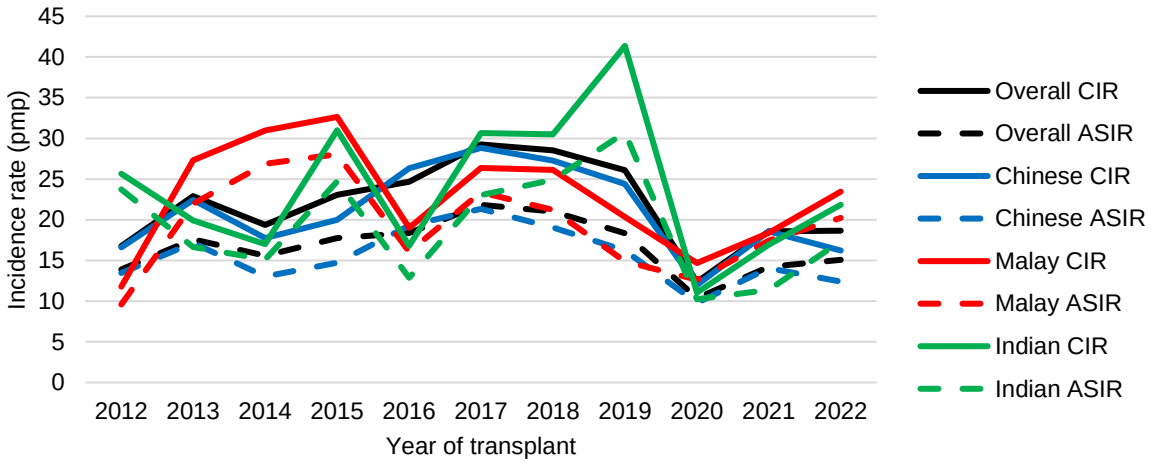


There was no ethnic group with consistently higher or lower incidence rates of kidney transplant across the years (Table 5.9.4 and Figure 5.9.5). In 2022, the ASIR was 12.4 pmp, 20.2 pmp and 17.3 pmp for Chinese, Malays and Indians respectively. The ASIRs for all the three ethnic groups fluctuated over the years due to the small number of transplants done each year.

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

Chinese				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2012	47	73.4	16.6	13.4
2013	64	72.7	22.4	17.2
2014	51	68.0	17.7	13.0
2015	58	64.4	20.0	14.7
2016	77	79.4	26.3	19.3
2017	85	73.3	28.8	21.3
2018	81	71.1	27.3	19.0
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
P for trend	-	-	0.596	0.469
Malay				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2012	6	9.4	11.8	9.6
2013	14	15.9	27.3	21.9
2014	16	21.3	31.0	26.9
2015	17	18.9	32.6	28.1
2016	10	10.3	19.0	16.0
2017	14	12.1	26.4	23.4
2018	14	12.3	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
P for trend	-	-	0.779	0.901
Indian				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2012	9	14.1	25.6	23.7
2013	7	8.0	19.9	16.7
2014	6	8.0	17.0	15.1
2015	11	12.2	31.0	24.7
2016	6	6.2	16.8	12.9
2017	11	9.5	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
P for trend	-	-	0.713	0.430

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



Most of the new kidney transplants were done locally, with 94.8% being local transplants in 2022 (Table 5.9.5). The percentage of living donors among local transplants has increased steadily from about 44% in 2017 to about 69% in 2022. Transplants done overseas were not further stratified into living or deceased donor as the registry does not have the data.

Transplants from living donors offer better outcomes[43]. Worldwide, the proportions of transplants coming from living donors differ, ranging from about a fifth in the United States to about nine-tenth in Japan[44].

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	%^
2012	28	54.9	23	45.1	51	79.7	13	20.3
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	80.0	18	20.0
2016	32	44.4	40	55.6	72	74.2	25	25.8
2017	41	43.6	53	56.4	94	81.0	22	19.0
2018	42	52.5	38	47.5	80	70.2	34	29.8
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

* Among local transplants
^ Among all transplants

[43] Hariharan S, Israni AK, Danovitch G. Long-Term Survival after Kidney Transplantation. N Engl J Med 2021;385:729-43.
[44] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/11-international-comparisons. Accessed 24 August 2023.

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 51.3% in 2022, while the proportion with DN was 22.4%. In contrast to trends for dialysis incidence, 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[45,46].

Table 5.9.6: Incidence number of kidney transplant by etiology

Year of transplant	DN		GN		Others	
	Number	%	Number	%	Number	%
2012	9	14.1	46	71.9	9	14.1
2013	8	9.1	55	62.5	25	28.4
2014	11	14.7	42	56.0	22	29.3
2015	18	20.0	49	54.4	23	25.6
2016	17	17.5	53	54.6	27	27.8
2017	20	17.2	70	60.3	26	22.4
2018	17	14.9	69	60.5	28	24.6
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	39	51.3	20	26.3

[45] Chantrel F et al. Abysmal prognosis of patients with type 2 diabetes entering dialysis. Nephrology Dialysis Transplant 1999; 14: 129-136.
[46] 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.

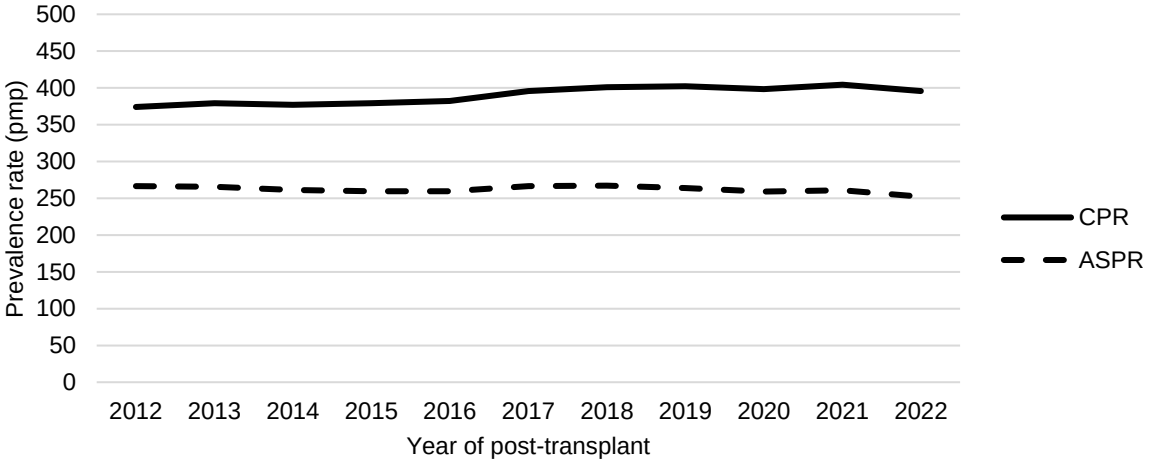
Unlike the incidence trend of kidney transplant which rose and dropped between 2012 and 2022 (Table 5.9.1 and Figure 5.9.1), the number of prevalent patients with kidney transplant generally increased since 2012 (Table 5.10.1 and Figure 5.10.1). There was a significant rise in CPR from 374.0 pmp in 2012 to 395.5 pmp in 2022 ($p<0.001$), while the ASPR remained stable and ranged between 252.2 pmp and 267.2 pmp during the same period. The stable ASPR trend suggests that the rise in new patients undergoing kidney transplant was fairly similar to the drop from those who died, after adjusting for Singapore's ageing population. Among countries included in USRDS data, in 2020, the United States had the highest prevalence of kidney transplants, followed by Spain, Portugal, and Norway, all of which had CPRs exceeding 700 pmp (compared to 398 pmp in Singapore)[47].

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

Year of post-transplant	Number	CPR	ASPR
2012	1428	374.0	266.5
2013	1457	379.0	265.8
2014	1459	376.9	261.5
2015	1479	379.0	259.7
2016	1504	382.4	259.7
2017	1569	395.6	266.4
2018	1602	401.1	267.2
2019	1620	402.4	264.0
2020	1610	398.1	259.2
2021	1612	404.3	260.8
2022	1611	395.5	252.2
P for trend	-	<0.001	0.077

[47] End Stage Renal Disease: Chapter 11 - International Comparisons. United States Renal Data System (USRDS). https://usrds-adr.niddk.nih.gov/2022/end-stage-renal-disease/11-international-comparisons. Accessed 24 August 2023.

Figure 5.10.1: Prevalence rate (pmp) of kidney transplant



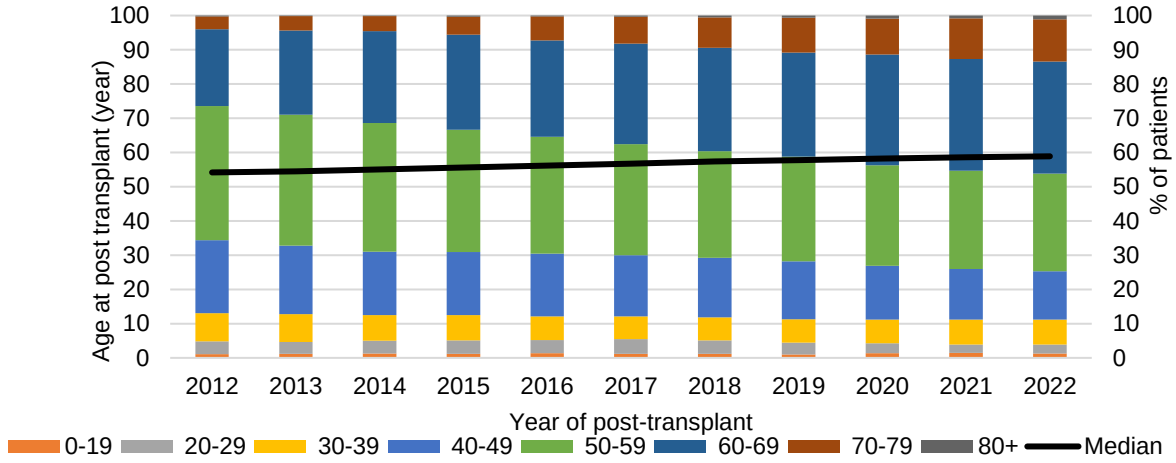
The CPR of kidney transplant increased for those aged 0 to 19 years (p=0.003), 60 to 69 years (p=0.038), 70 to 79 years (p<0.001) and 80 years and above (p<0.001), but it dropped for those aged 40-49 years (p=0.003) and 50-59 years (p<0.001) (Table 5.10.2).

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
2012	16	1.1	18.1	53	3.7	102.1	118	8.3	193.7	304	21.3	482.8
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	272	18.4	438.6
2016	20	1.3	23.9	58	3.9	107.2	104	6.9	177.0	276	18.4	449.1
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	279	17.4	456.3
2019	16	1.0	19.7	56	3.5	104.2	111	6.9	186.8	274	16.9	447.4
2020	22	1.4	27.4	46	2.9	86.5	112	7.0	187.5	253	15.7	414.1
2021	23	1.4	29.4	40	2.5	77.6	118	7.3	199.9	238	14.8	401.4
2022	21	1.3	26.6	41	2.5	79.9	118	7.3	194.0	228	14.2	377.4
P for trend	-	-	0.003	-	-	0.099	-	-	0.712	-	-	0.003
Year of post-transplant	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CPR	Number	%	CPR	Number	%	CPR	Number	%	CPR
2012	560	39.2	961.9	320	22.4	933.5	54	3.8	314.0	3	0.2	38.7
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	35.8	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	510	32.5	830.0	460	29.3	985.8	123	7.8	581.7	6	0.4	59.2
2018	499	31.1	813.6	484	30.2	1000.4	143	8.9	624.8	8	0.5	74.8
2019	495	30.6	813.6	493	30.4	985.8	165	10.2	674.2	10	0.6	86.5
2020	473	29.4	785.8	521	32.4	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	199	12.4	676.0	17	1.1	125.2
P for trend	-	-	<0.001	-	-	0.038	-	-	<0.001	-	-	<0.001

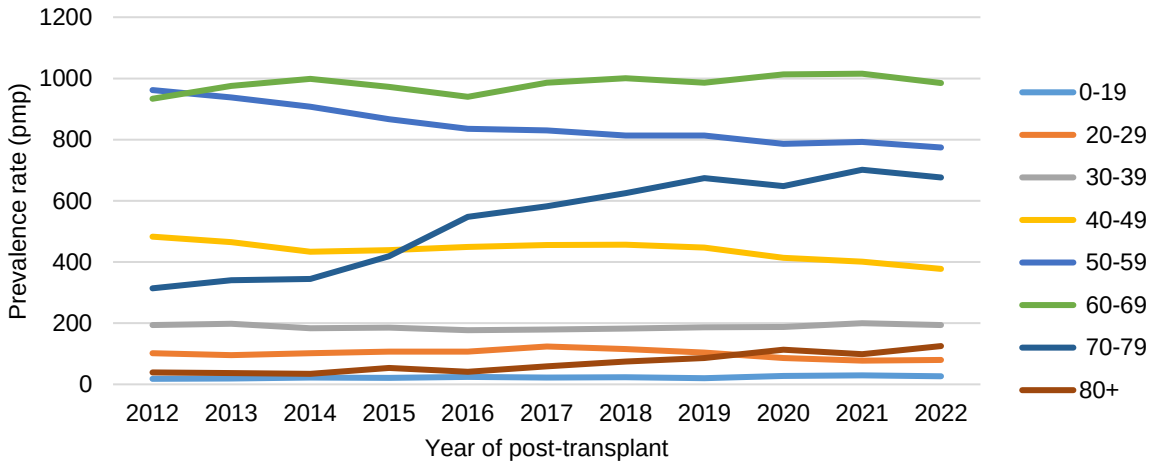
The median age among prevalent kidney transplant patients increased from 54.2 years in 2012 to 58.9 years in 2022; the percentage of kidney transplant patients aged 60 years and above also rose from 26.4% in 2012 to 46.3% in 2022 (Figure 5.10.2a).

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



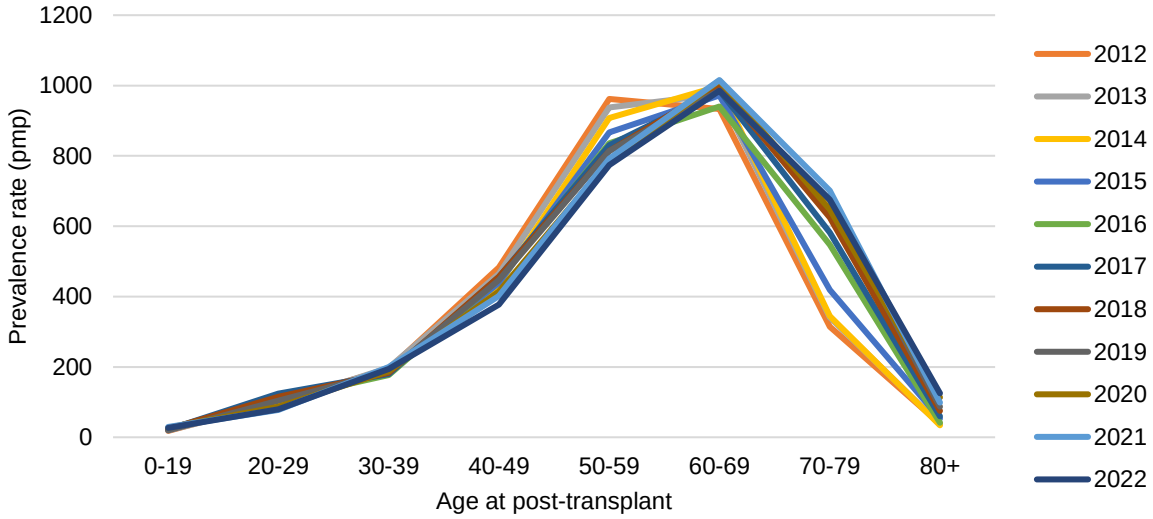
The age-specific prevalence rate of kidney transplant was highest for those aged 60 to 69 years since 2013 (Figure 5.10.2b).

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



Prior to 2013, the age-specific CPR of kidney transplant peaked for those aged 50 to 59 years. However, the peak shifted to those aged 60 to 69 years since 2013 (Figure 5.10.3).

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



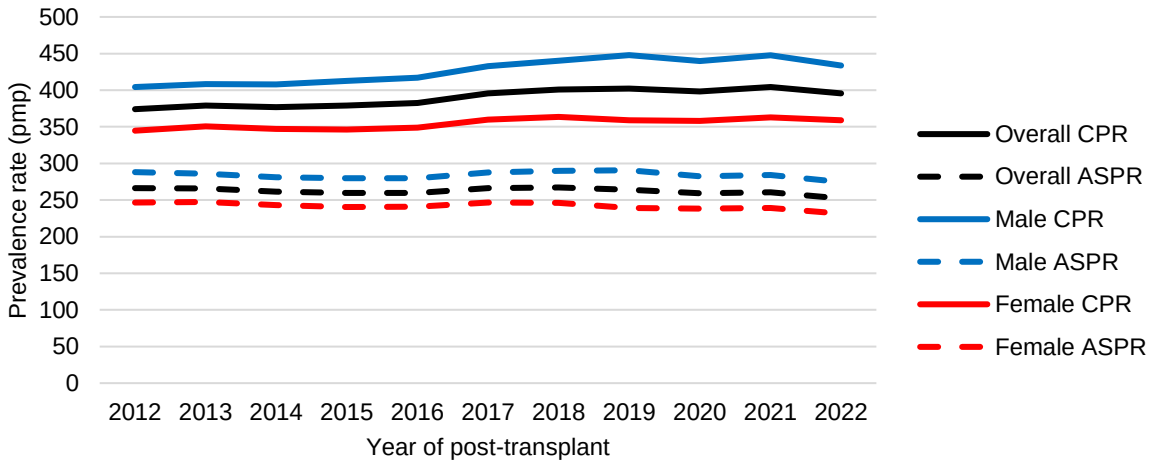
The sex makeup of prevalent kidney transplant patients each year did not differ significantly from that of prevalent dialysis patients. The ASPRs of kidney transplant were consistently higher among males than females across the years (Table 5.10.3 and Figure 5.10.4). In 2022, the ASPR was 274.6 pmp and 231.4 pmp for males and females respectively. The ASPR for males remained stable, while the ASPR for females dropped significantly over the years (p=0.007).

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

Male				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2012	760	53.2	404.3	287.9
2013	772	53.0	408.2	285.7
2014	776	53.2	407.9	281.0
2015	791	53.5	412.7	279.9
2016	805	53.5	417.2	279.8
2017	841	53.6	432.7	287.8
2018	861	53.7	440.2	289.8
2019	882	54.4	447.9	290.7
2020	870	54.0	439.9	282.2
2021	874	54.2	447.5	284.2
2022	863	53.6	433.6	274.6
P for trend	-	-	<0.001	0.495

Female				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2012	668	46.8	344.7	246.5
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	46.5	348.8	240.8
2017	728	46.4	360.0	246.5
2018	741	46.3	363.5	246.1
2019	738	45.6	358.8	239.2
2020	740	46.0	358.1	238.1
2021	738	45.8	362.9	239.3
2022	748	46.4	359.1	231.4
P for trend	-	-	0.002	0.007

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

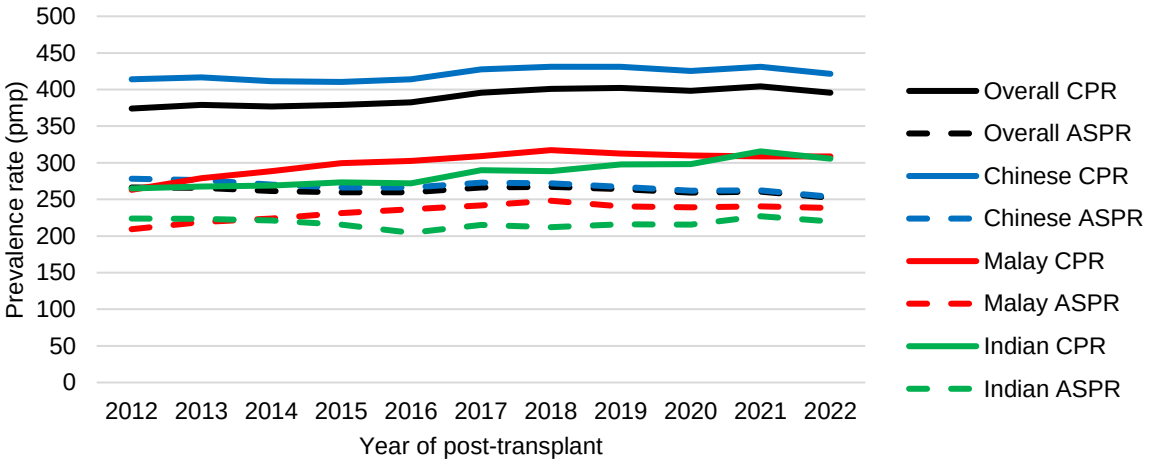


The ASPRs of kidney transplant were consistently higher among Chinese than Malays and Indians across the years (Table 5.10.4 and Figure 5.10.5). While the ASPR for Chinese dropped significantly from 278.2 pmp in 2012 to 253.6 pmp in 2022 (p=0.001), the ASPR for Malays increased significantly from 209.3 pmp in 2012 to 238.4 pmp in 2022 (p=0.003) and the ASPR for Indians remained stable and ranged between 204.5 pmp and 227.0 pmp in the past decade.

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

Chinese				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2012	1172	82.1	413.9	278.2
2013	1189	81.6	416.6	276.5
2014	1183	81.1	411.6	270.1
2015	1190	80.5	410.3	266.1
2016	1210	80.5	413.9	266.1
2017	1260	80.3	427.4	272.8
2018	1280	79.9	431.1	271.8
2019	1290	79.6	430.9	267.1
2020	1279	79.4	425.4	262.0
2021	1276	79.2	431.1	262.2
2022	1272	79.0	421.3	253.6
P for trend	-	-	0.014	0.001
Malay				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2012	134	9.4	263.1	209.3
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	10.5	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
P for trend	-	-	0.002	0.003
Indian				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2012	93	6.5	265.0	223.8
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	7.0	305.7	219.8
P for trend	-	-	<0.001	0.855

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



Most of the prevalent kidney transplants were done locally, with 75.4% being local transplants in 2022 (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 into living or deceased donor 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	%
2012	404	28.3	589	41.3	435	30.5
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	430	29.1
2016	485	32.3	585	38.9	434	28.9
2017	508	32.4	616	39.3	445	28.4
2018	527	32.9	629	39.3	446	27.8
2019	563	34.8	624	38.5	433	26.7
2020	575	35.7	611	38.0	424	26.3
2021	607	37.7	588	36.5	417	25.9
2022	639	39.7	575	35.7	397	24.6

The proportion of prevalent kidney transplant patients with DN was lower than those with GN (Table 5.10.6). However, while the proportion of prevalent transplant patients with DN increased from 7.9% in 2012 to 11.2% in 2022, those with GN dropped from 71.0% in 2012 to 65.5% in 2022.

Table 5.10.6: Prevalence number of kidney transplant by etiology

Year of post-transplant	DN		GN		Others	
	Number	%	Number	%	Number	%
2012	113	7.9	1014	71.0	301	21.1
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	321	21.7
2016	141	9.4	1035	68.8	328	21.8
2017	152	9.7	1074	68.5	343	21.9
2018	155	9.7	1092	68.2	355	22.2
2019	171	10.6	1084	66.9	365	22.5
2020	168	10.4	1073	66.6	369	22.9
2021	173	10.7	1059	65.7	380	23.6
2022	180	11.2	1055	65.5	376	23.3

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 2023. Median survival duration is indicated as “not reached (NR)” if more than half of the patients did not suffer from graft loss and were still alive as of 30 April 2023. 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 2023. Median survival duration is indicated as “not reached (NR)” if more than half of the patients were alive as of 30 April 2023. 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 2023 (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 97.6%, 89.5% and 76.0% respectively (Table 5.11.1). 1-, 5- and 10-year patient survival were also high at 98.4%, 93.5% and 84.8% respectively and outperformed patients on dialysis (90.7%, 56.9% and 29.6% 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 (%)	97.6	98.4
5-year survival (%)	89.5	93.5
10-year survival (%)	76.0	84.8
Median survival (years)	19.7	NR

Among patients with transplants done locally, those who received kidney 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[48]. 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[49].

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

	Living		Deceased	
	Graft	**Patient**	**Graft**	**Patient**
1-year survival (%)	99.3	99.3	96.3	97.6
5-year survival (%)	93.8	96.0	85.7	91.1
10-year survival (%)	82.8	89.1	67.9	80.7
Median survival (years)	NR	NR	15.4	22.8

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 (%)	97.9	98.7	95.5	95.9
5-year survival (%)	90.1	94.3	84.0	86.0
10-year survival (%)	77.0	86.5	66.2	67.6
Median survival (years)	20.0	NR	14.8	15.4

Although patient survival were fairly similar between the two sexes, female patients had significantly better graft survival (p=0.023) than male patients (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	97.8	98.4
5-year survival (%)	89.1	93.7	89.9	93.3
10-year survival (%)	74.6	84.5	77.8	85.2
Median survival (years)	18.1	NR	22.7	NR

[48] Wang JH and Hart A. Global Perspective on Kidney Transplantation: United States. KIDNEY360 2; 2021. 1836–1839.
[49] 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	98.5	96.4	97.2	98.2	98.8
5-year survival (%)	90.8	94.1	85.3	92.3	83.0	90.2
10-year survival (%)	78.3	85.1	67.4	85.3	64.3	80.2
Median survival (years)	20.4	NR	15.3	22.0	12.7	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[50]. 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	98.5	96.9	97.6
5-year survival (%)	90.3	94.4	83.9	87.4
10-year survival (%)	77.3	86.4	66.8	73.3
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 (%)	97.8	98.5	96.9	97.6
5-year survival (%)	90.3	94.4	83.9	87.4
10-year survival (%)	77.3	86.4	66.8	73.3
Median survival (years)	20.8	NR	12.8	15.3

Graft survival was not significantly different between patients without CVD and those with CVD, but patient survival was comparatively better among kidney transplant patients without CVD (p=0.006) (Table 5.11.8).

[50] 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 (%)	98.0	98.7	91.2	94.5
5-year survival (%)	89.8	93.7	87.6	92.0
10-year survival (%)	76.2	85.2	76.4	79.1
Median survival (years)	19.9	NR	14.8	NR

Patients without PVD had significantly better patient (p=0.001) 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	98.5	94.5	97.3
5-year survival (%)	89.8	93.8	85.3	88.1
10-year survival (%)	76.3	85.2	74.9	72.5
Median survival (years)	19.9	NR	12.9	NR

There was no significant difference in graft and patient 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 (%)	97.9	98.7	96.7	96.7
5-year survival (%)	90.4	94.4	82.1	87.4
10-year survival (%)	76.8	85.7	70.6	75.4
Median survival (years)	19.7	NR	NR	NR

Among patients with transplants done locally, transplant from deceased donor, older age, presence of DN and IHD 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	2.69	2.03-3.55	
Age group			
<60 years	1.00	Reference	<0.001
⩾60 years	3.21	2.09-4.92	
Sex			
Male	1.00	Reference	0.650
Female	0.95	0.75-1.20	
Ethnicity			
Chinese	1.00	Reference	
Malay	1.13	0.83-1.55	0.441
Indian	1.51	1.01-2.25	0.045
Etiology			
Non-DN	1.00	Reference	<0.001
DN	2.77	1.85-4.14	
IHD			
No	1.00	Reference	0.003
Yes	1.62	1.18-2.22	
CVD			
No	1.00	Reference	0.278
Yes	1.42	0.76-2.65	
PVD			
No	1.00	Reference	0.193
Yes	1.61	0.79-3.27	
Cancer			
No	1.00	Reference	0.700
Yes	1.16	0.54-2.48	

Aside from transplant patients, Table 5.11.12 also included dialysis patients without transplant. Patients with kidney transplant, be it from living or deceased donors, had significantly lower risk of death than dialysis patients without transplant. Older age, 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	0.16-0.25	<0.001
Transplant from deceased donor	0.46	0.40-0.53	<0.001
Age group			
<60 years	1.00	Reference	<0.001
⩾60 years	1.86	1.79-1.93	
Sex			
Male	1.00	Reference	0.595
Female	0.99	0.95-1.03	
Ethnicity			
Chinese	1.00	Reference	
Malay	0.89	0.85-0.93	<0.001
Indian	0.97	0.91-1.04	0.445
Etiology			
Non-DN	1.00	Reference	<0.001
DN	1.67	1.60-1.74	
IHD			
No	1.00	Reference	<0.001
Yes	1.47	1.41-1.53	
CVD			
No	1.00	Reference	<0.001
Yes	1.32	1.27-1.38	
PVD			
No	1.00	Reference	<0.001
Yes	1.47	1.40-1.54	
Cancer			
No	1.00	Reference	<0.001
Yes	1.39	1.30-1.48	

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[51,52]. 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.

[51] Tonelli M. et al. Systematic Review: Kidney Transplantation Compared With Dialysis in Clinically Relevant Outcomes. American Journal of Transplantation 2011; 11: 2093–2109.
[52] 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 2022

Public hospitals and affiliated dialysis centres	HD	PD	Transplant
SINGAPORE GENERAL HOSPITAL	24	480	809
TAN TOCK SENG RENAL CENTRE	12	148	36
CHANGI GENERAL HOSPITAL	7	74	1
KHOO TECK PUAT HOSPITAL	7	124	0
NG TENG FONG GENERAL HOSPITAL	13	52	0
SENGKANG GENERAL HOSPITAL	9	60	0
NATIONAL UNIVERSITY HOSPITAL	5	167	573
NUH DIALYSIS CENTRE	60	0	0
NUH RENAL CENTRE	17	0	0
SHAW NKF - NUH CHILDREN'S KIDNEY CENTRE	4	15	45
Subtotal	**158**	**1120**	**1464**
Voluntary Welfare Organisations	**HD**	**PD**	**Transplant**
ANG MO KIO THYE HUA KWAN HOSPITAL DIALYSIS CENTRE	68	0	0
FOO HAI - NKF DIALYSIS CENTRE	74	0	0
HONG LEONG - NKF DIALYSIS CENTRE (ALJUNIED CRESCENT)	106	0	0
IFPAS - NKF DIALYSIS CENTRE (SERANGOON)	104	0	0
IHSAN KIDNEY CARE (IKC)	64	0	0
JO & GERRY ESSERY NKF DIALYSIS CENTRE (BLK 204 MARSILING)	126	0	0
KWAN IM THONG HOOD CHO TEMPLE - NKF DIALYSIS CENTRE (KOLAM AYER)	144	0	0
KWAN IM THONG HOOD CHO TEMPLE - NKF DIALYSIS CENTRE (SIMEI)	156	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	87	0	0
NKF DIALYSIS CENTRE (BLK 365 WOODLANDS II)	111	0	0
NKF DIALYSIS CENTRE SUPPORTED BY KEPPEL	96	0	0
NKF DIALYSIS CENTRE SUPPORTED BY MAN FATT LAM BUDDHIST TEMPLE (105 BEDOK NORTH)	95	0	0
NKF DIALYSIS CENTRE SUPPORTED BY NGIAM KIA HUM & FAMILY	204	0	0
NKF DIALYSIS CENTRE SUPPORTED BY TL WHANG FOUNDATION	129	0	0

NKF HOUGANG PUNGGOL DIALYSIS CENTRE	120	0	0
NKF INTEGRATED RENAL CENTRE (CP1)	214	0	0
NKF INTEGRATED RENAL CENTRE (CP2)	28	0	0
NKF JURONG EAST DIALYSIS CENTRE SUPPORTED BY YUHUA GRASSROOTS ORGANISATIONS	125	0	0
NTUC INCOME - NKF DIALYSIS CENTRE (BUKIT BATOK)	88	0	0
NTUC/SINGAPORE POOLS - NKF DIALYSIS CENTRE (TAMPINES)	140	0	0
PEI HWA FOUNDATION - NKF DIALYSIS CENTRE (ANG MO KIO)	120	0	0
QUEENSTOWN - NKF DIALYSIS CENTRE	146	0	0
SAF - NKF DIALYSIS CENTRE (CLEMENTI)	118	0	0
SAKYADHITA -NKF DIALYSIS CENTRE (UPPER BOON KENG)	103	0	0
SCAL - NKF DIALYSIS CENTRE (YISHUN)	70	0	0
SECK HONG CHOON - NKF DIALYSIS CENTRE	62	0	0
SHENG HONG TEMPLE - NKF DIALYSIS CENTRE (JURONG WEST)	118	0	0
SIA - NKF DIALYSIS CENTRE (TOA PAYOH)	53	0	0
SINGAPORE BUDDHIST WELFARE SERVICES - NKF DIALYSIS CENTRE (HOUGANG)	0	0	0
SINGAPORE POOLS - NKF DIALYSIS CENTRE (BEDOK)	115	0	0
TAMPINES CHINESE TEMPLE - NKF DIALYSIS CENTRE (PASIR RIS)	104	0	0
TAY CHOON HYE - NKF DIALYSIS CENTRE (KIM KEAT)	122	0	0
THE HOUR GLASS - NKF DIALYSIS CENTRE (WEST COAST)	69	0	0
THE HOUR GLASS NKF DIALYSIS CENTRE (ADMIRALTY BRANCH)	104	0	0
THE SINGAPORE BUDDHIST LODGE - NKF DIALYSIS CENTRE (128 BUKIT MERAH VIEW)	99	0	0
THE SIRIVADHANABHAKDI FOUNDATION NKF DIALYSIS CENTRE (JW2)	117	0	0
THONG TECK SIAN TONG LIAN SIN SIA - NKF DIALYSIS CENTRE (WOODLANDS)	118	0	0
TOA PAYOH SEU TECK SEAN TONG - NKF DIALYSIS CENTRE (YISHUN)	75	0	0
WESTERN DIGITAL - NKF DIALYSIS CENTRE (ANG MO KIO)	157	0	0
WOH HUP - NKF DIALYSIS CENTRE (GHIM MOH)	0	0	0
WONG SUI HA EDNA - NKF DIALYSIS CENTRE	132	0	0
KDF - BISHAN CENTRE	91	0	0
KDF - GHIM MOH CENTRE (HD)	84	0	0
KDF - KRETA AYER (HD)	72	0	0
KDF - SAN WANG WU TI CENTRE @ ADMIRALTY LINK	20	0	0

Subtotal	**4860**	**0**	**0**
Private clinics and dialysis centres	**HD**	**PD**	**Transplant**
ADVANCE DIALYSIS SERVICES PTE LTD	0	0	0
ADVANCE RENAL CARE (KOVAN) PTE LTD	0	0	0
ADVANCE RENAL CARE (NOVENA)	0	0	0
AEGIS DIALYSIS CENTRE	40	0	0
ARCA (FARRER PARK) DIALYSIS PTE LTD	27	0	0
ASIA KIDNEY DIALYSIS CENTRE (BEDOK)	74	0	0
ASIA KIDNEY DIALYSIS CENTRE (JURONG)	39	0	0
ASIA KIDNEY DIALYSIS CENTRE (TAMPINES) BLK 139	90	0	0
ASIA KIDNEY DIALYSIS CENTRE (TECK WHYE)	43	0	0
ASIA KIDNEY DIALYSIS CENTRE (TP) BLK-484	51	0	0
ASIA KIDNEY DIALYSIS CENTRE (TPY)	43	0	0
COMPLEX MEDICAL CENTRE (CHANGI)	3	0	0
DAVITA MEDICAL & DIALYSIS CENTRE (EAST COAST)	41	0	0
DAVITA MEDICAL & DIALYSIS CENTRE (JURONG EAST)	34	0	0
DAVITA MEDICAL AND DIALYSIS CENTRE @ FARRER PARK MEDICAL CENTRE	54	0	0
DAVITA MEDICAL AND DIALYSIS CENTRE @ ROYAL SQUARE MEDICAL SUITES (NOVENA)	50	0	0
DIAVERUM DIALYSIS CENTRE TAMPINES	41	0	0
DIAVERUM KOVAN DIALYSIS CENTRE	50	0	0
DIAVERUM NOVENA DIALYSIS CENTRE	7	0	0
DIAVERUM TAMPINES II DIALYSIS CENTRE	3	0	0
DIAVERUM TOWNER DIALYSIS CENTRE	26	0	0
ECON ADVANCE RENAL CARE (YUNG KUANG)	0	0	0
ECON ADVANCE RENAL CARE PTE LTD (BEDOK)	0	0	0
FRESENIUS KIDNEY CARE YISHUN DIALYSIS CLINIC	45	0	0
FRESENIUS KIDNEY CARE ANG MO KIO 128 DIALYSIS CLINIC	26	0	0
FRESENIUS KIDNEY CARE ANG MO KIO DIALYSIS CLINIC (BLK 422)	40	0	0
FRESENIUS KIDNEY CARE ANG MO KIO DIALYSIS CLINIC (BLK 443)	33	0	0
FRESENIUS KIDNEY CARE BEDOK DIALYSIS CLINIC	37	0	0
FRESENIUS KIDNEY CARE BEDOK RESERVOIR DIALYSIS CLINIC	53	0	0
FRESENIUS KIDNEY CARE BUANGKOK DIALYSIS CLINIC	69	0	0
FRESENIUS KIDNEY CARE BUKIT BATOK DIALYSIS CLINIC (BLK 213)	53	0	0

FRESENIUS KIDNEY CARE BUKIT MERAH CENTRAL DIALYSIS CLINIC	17	0	0
FRESENIUS KIDNEY CARE BUKIT MERAH DIALYSIS CLINIC	29	0	0
FRESENIUS KIDNEY CARE CLEMENTI DIALYSIS CLINIC	22	0	0
FRESENIUS KIDNEY CARE EAST COAST DIALYSIS CLINIC	41	0	0
FRESENIUS KIDNEY CARE FENGSHAN DIALYSIS CLINIC	27	0	0
FRESENIUS KIDNEY CARE JURONG BOON LAY DIALYSIS CLINIC (BLK 353)	41	0	0
FRESENIUS KIDNEY CARE JURONG EAST CENTRAL DIALYSIS CLINIC (BLK 104)	46	0	0
FRESENIUS KIDNEY CARE JURONG EAST DIALYSIS CLINIC (BLK 326)	51	0	0
FRESENIUS KIDNEY CARE KEMBANGAN DIALYSIS CLINIC	48	0	0
FRESENIUS KIDNEY CARE KHATIB DIALYSIS CLINIC	41	0	0
FRESENIUS KIDNEY CARE KOVAN DIALYSIS CLINIC	44	0	0
FRESENIUS KIDNEY CARE MARSILING DIALYSIS CLINIC	42	0	0
FRESENIUS KIDNEY CARE MT ELIZABETH DIALYSIS CLINIC	18	0	0
FRESENIUS KIDNEY CARE NAPIER DIALYSIS CLINIC	17	0	0
FRESENIUS KIDNEY CARE RENCI DIALYSIS CLINIC	41	0	0
FRESENIUS KIDNEY CARE SERANGOON DIALYSIS CLINIC	75	0	0
FRESENIUS KIDNEY CARE TAMPINES DIALYSIS CLINIC	44	0	0
FRESENIUS KIDNEY CARE TAMPINES WEST DIALYSIS CLINIC	43	0	0
FRESENIUS KIDNEY CARE TANGLIN DIALYSIS CLINIC	25	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)	20	0	0
FRESENIUS KIDNEY CARE WHAMPOA DIALYSIS CLINIC	43	0	0
FRESENIUS KIDNEY CARE WOODLANDS DIALYSIS CLINIC	44	0	0
FRESENIUS KIDNEY CARE WOODLANDS PEAK DIALYSIS CLINIC	2	0	0
FRESENIUS KIDNEY CARE YISHUN RING DIALYSIS CLINIC	41	0	0
FRESENIUS MEDICAL CARE TAMPINES DIALYSIS CLINIC (BLK 107)	0	0	0

GLENEAGLES HOSPITAL	2	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)	24	0	0
IMMANUEL DIALYSIS CENTRE PTE LTD (WOODLANDS)	34	0	0
IMMANUEL DIALYSIS CENTRE PTE LTD (YISHUN)	27	0	0
KIDNEY THERAPEUTICS CENTRE PTE LTD	15	0	0
KIDNEYCARE DIALYSIS CENTRE @ PASIR RIS	50	0	0
KIDNEYCARE DIALYSIS CENTRE @ WEST COAST	24	0	0
KIDNEYCARE DIALYSIS CENTRE @ YISHUN	38	0	0
PACIFIC ADVANCE RENAL CARE (CHOA CHU KANG)	45	0	0
PACIFIC ADVANCE RENAL CARE (FAJAR)	41	0	0
PACIFIC ADVANCE RENAL CARE (SENG KANG)	40	0	0
PACIFIC ADVANCE RENAL CARE PTE LTD (PUNGGOL WAY)	43	0	0
PACIFIC ADVANCE RENAL CARE PTE LTD (TAMPINES)	0	0	0
PACIFIC ADVANCE RENAL CARE PTE LTD (WOODLANDS)	51	0	0
RAFFLES DIALYSIS CENTRE	16	0	0
RENAL HEALTH PTE LTD	57	0	0
RENAL LIFE (ALEXANDRA) DIALYSIS CENTRE PTE LTD	15	0	0
RENAL LIFE (HOUGANG) DIALYSIS CENTRE PTE LTD	24	0	0
RENAL LIFE (W) DIALYSIS CENTRE PTE LTD (BLK 207 BUKIT BATOK)	32	0	0
RENAL LIFE DIALYSIS CENTRE PTE LTD (BLK 463 JURONG WEST)	23	0	0
RENAL LIFE(PIONEER) DIALYSIS CENTRE PTE LTD	39	0	0
CENTRE FOR KIDNEY DISEASE PTE LTD (LUCKY PLAZA)	0	1	39
GRACE LEE RENAL AND MEDICAL CLINIC PTE LTD	0	4	7
KIDNEY & MEDICAL CENTRE	0	0	5
KIDNEY LIFE CENTRE	0	1	6
MOUNT ELIZABETH HOSPITAL	0	0	0
RAFFLES HOSPITAL	1	0	2
ROGER KIDNEY CLINIC	0	0	6
SH TAN KIDNEY & MEDICAL CLINIC	0	2	3
STEPHEW CHEW CENTRE FOR KIDNEY DISEASE AND HYPERTENSION (MAH)	0	0	17

STEPHEW CHEW CENTRE FOR KIDNEY DISEASE AND HYPERTENSION (MEH)	0	0	4
T.G. NG KIDNEY & MEDICAL CENTRE	0	0	2
TAL DIALYSIS CLEMENTI	40	0	0
THE KIDNEY & TRANSPLANT PRACTICE	0	5	4
THE KIDNEY CLINIC PTE LTD	0	0	11
THE KIDNEY HEALTH CLINIC PTE LTD	0	0	1
THE SINGAPORE CLINIC FOR KIDNEY DISEASES	0	0	3
UNKNOWN PRIVATE NEPHROLOGY CLINIC	0	0	1
WU NEPHROLOGY & MEDICAL CLINIC (WU MEDICAL CLINIC PTE LTD)	0	0	36
Subtotal	**2727**	**13**	**147**
Grand total	**7745**	**1133**	**1611**