Singapore Renal Registry Annual Report 2017

National Registry of Diseases Office 20 Aug 2019

Acknowledgement

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

National Registry of Diseases Office

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1. GLOSSARY

ASIR	Age standardized incidence rate
ASPR	Age standardized 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 Organization

2. EXECUTIVE SUMMARY

The crude incidence rate (CIR) of chronic kidney disease stage 5 (CKD5) increased significantly from 347.8 per million population (pmp) in 2008 to 480.2 pmp in 2016. While the age standardized incidence rate (ASIR) of CKD5 remained relatively stable, ranging between 255 pmp and 296 pmp in 2008 to 2017, the ASIR of definitive dialysis increased significantly from 164.5 pmp in 2008 to 180.2 pmp in 2017. The age standardized prevalence rate (ASPR) of definitive dialysis also increased significantly from 884.0 pmp in 2008 to 1059.2 pmp in 2017.

Men outnumbered women in both incidence and prevalence rates of dialysis. The Malays had the highest incidence and prevalence rates of dialysis. Haemodialysis (HD) was the main modality among incident and prevalent dialysis patients. Diabetic nephropathy (DN) was the main cause of CKD5 among incident and prevalent dialysis patients.

Cardiac event and infection were the two common causes of death among prevalent dialysis patients. The risk of death was higher for peritoneal dialysis (PD). However, the disparity in survival between HD and PD narrowed over the years.

Frequency of dialysis, management of urea, management of anaemia, and management of mineral and bone disease among prevalent dialysis patients were assessed. 98.6% of the HD patients had thrice weekly dialysis in 2017. Urea was well managed in 95.8% of the HD patients and 45.0% of the PD patients based on their urea reduction ratio or fractional clearance of urea in 2017. Anaemia was well managed in 80.3% of the HD patients and 66.1% of the PD patients based on their haemoglobin level in 2017. Bone metabolism was well managed in 51.6%, 56.5% and 23.3% of the HD patients and 52.0%, 53.6% and 31.2% of the PD patients based on their calcium level, phosphate level and intact parathyroid hormone level respectively in 2017.

The ASIR of kidney transplant was 23.0 pmp in 2008, declined to 13.9 pmp in 2012 (lowest point during the past decade), and increased to 21.2 pmp in 2017. The ASPR of transplant remained relatively stable, ranging between 258.6 pmp and 270.2 pmp in the same period.

Men outnumbered women in both incidence and prevalence rates of kidney transplant. While no distinct ethnic difference was found with regard to the incidence rate of transplant, the Chinese had the highest prevalence rate of transplant. Glomerulonephritis (GN) was the main cause of CKD5 for incident and prevalent transplant patients. Most of the transplants were done locally, with a higher contribution from deceased donors than living donors.

Graft and patient survival were better among transplants from living donors than deceased donors. Transplant patients, regardless of the type of donor, had better survival than dialysis patients.

3. INTRODUCTION

CKD is a worldwide epidemic[1], with diabetes as its leading cause. In Singapore, 2.3% of the residents aged between 18 and 69 years old had CKD in 2010 based on the National Health Survey 2010[2]. It also showed that the crude prevalence of diabetes increased from 8.6% in 1992 to 11.3% in 2010. In 2010, one in two diabetics were undiagnosed and one in three known diabetics had poor blood sugar control. The situation in Singapore is further compounded by our ageing population, whereby decline in kidney function rises with age[3]. The old-age support ratio dropped from 8.4 people aged 15 to 64 per person aged 65 years or above in 2008 to 5.5 in 2017[4]. With the rise in the number of people with diabetes and old age, the economic burden due to CKD in Singapore is expected to escalate.

Estimated glomerular filtration rate (eGFR; glomerular filtration rate corrected to the body surface area of $1.73m^2$) is one of the markers of kidney damage. Internationally, CKD is defined as eGFR less than 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 CKD5 patients who were on renal replacement therapy (i.e. dialysis or kidney transplant). There are two main modality of dialysis: HD and PD. Patients who are older and have medical conditions are preferentially placed on PD, a gentler therapy than 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 Health Survey 2010. Ministry of Health, Singapore.
[3] Ayodele OE and Alebiosu CO. Burden of chronic kidney disease: an international perspective. Advanced Chronic Kidney Disease. 2010; 17(3): 215-224.
[4] Population Trends 2017. Department of Statistics, Singapore.

4. METHODOLOGY

The National Registry of Diseases Office collects and analyses epidemiological data to support policy planning and programme evaluation.

In most renal registries, only patients who initiated dialysis are captured. There are also others, such as the United States Renal Data System, which capture only patients who survived >90 days after initiation on dialysis. However, these registries may underestimate the burden of kidney failure in the country and the workload of healthcare professionals. As such, the Singapore Renal Registry (SRR) started capturing patients with CKD5 since 1999, regardless whether they initiated dialysis or survived >90 days after initiation of dialysis.

In 2007, the Singapore General Hospital, which contributes about 50% of the new CKD5 cases each year, started to provide the SRR their list of patients with eGFR <15 ml/min/1.73m^2. 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.

<u>Data sources</u>

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

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, 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 for at least six months before accepting the case as CKD5. The monitoring period is to allow for the eGFR readings to stabilize 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[5].

The registry coordinators confirm the diagnosis of CKD5 by viewing the patients' case notes and electronic medical records, before extracting relevant detailed clinical information from the case notes and electronic medical records at the healthcare institutions.

The death status of all patients registered in the SRR were updated till 28 February 2018 by matching the patients' unique national registration identity card number with the death information imported from the Ministry of Home Affairs.

[5] Chronic Kidney Disease: Evaluation, Classification, and Stratification 2002. National Kidney Foundation, New York.

Population estimates

The Singapore population estimates used to calculate the incidence rate and prevalence rate 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[6]. The Segi World population estimates used for age standardization are available on the World Health Organization website[7].

This report focuses on Singapore residents diagnosed with CKD5, undergoing dialysis or received transplant in 2008 to 2017, as they stood on 30 April 2018. For survival, a longer observation period - 1999 to 2017, was used to assess short-term (1-year) and long-term (10-year) survival.

[6] SingStat Table Builder, Population and Population Structure, Annual Population, Singapore Residents by age group, ethnic group and sex. Department of Statistics, Singapore.
[7] 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 last five years - 2013 to 2017. The number of new and prevalent dialysis and kidney transplant patients increased over the years. While the number of deaths among dialysis patients also increased, the number of deaths among transplant patients dropped over time.

Table 5.1.1: Stock and flow in 2013 – 2017

	2013	2014	2015	2016	2017
Incidence					
Definitive dialysis	977	1041	1090	1170	1175
Transplant	88	76	90	95	112
Death					
Definitive dialysis	773	764	799	800	878
Transplant	39	32	35	26	20
Prevalence					
Definitive dialysis	5521	5879	6230	6671	7007
Transplant	1452	1455	1475	1498	1561

As of the end of 2017, the majority of the prevalent HD patients were dialysed in centres run by the Voluntary Welfare Organizations (VWO; 62.3%), followed by the private sector (36.1%), then the public sector (1.6%) (Table 5.1.2).

On the contrary, almost all of the prevalent PD patients were cared for by the public sector (99.7%), with no patient under the care of the VWO.

Detailed breakdown of the prevalent patients by service providers is shown in Table 5.1.3.

Table 5.1.2: Prevalent patients as of 31 December 2017

	HD		PD		Transplant	
	Number	%	Number	%	Number	%
Public hospitals and affiliated dialysis centres	100	1.6	891	99.7	1408	90.2
Voluntary Welfare Organizations	3807	62.3	0	0.0	0	0.0
Private clinics and dialysis centres	2206	36.1	3	0.3	152	9.7
Overseas	0	0.0	0	0.0	1	0.1
Total	**6113**	**100.0**	**894**	**100.0**	**1561**	**100.0**

Table 5.1.3: Prevalent patients by service providers as of 31 December 2017

Public hospitals and affiliated dialysis centres	HD	PD	Transplant
Alexandra Hospital	0	0	0
Changi General Hospital	2	52	2
Khoo Teck Puat Hospital	0	82	0
National University Hospital	8	184	502
NUH Dialysis Centre	58	0	0
NUH Renal Centre	20	0	0
Shaw NKF - NUH Children's Kidney Centre	4	14	46
Ng Teng Feng General Hospital	0	46	0
Singapore General Hospital	5	389	819
Tan Tock Seng Renal Centre	3	124	39
Sub-total	**100**	**891**	**1408**
Voluntary Welfare Organizations	**HD**	**PD**	**Transplant**
Ang Mo Kio Thye Hua Kwan Hospital Dialysis Centre	39	0	0
Hong Leong - NKF Dialysis Centre (Aljunied Crescent)	104	0	0
IFPAS - NKF Dialysis Centre (Serangoon)	103	0	0
Japan Airline - NKF Dialysis Centre (Ang Mo Kio)	122	0	0
KDF – Bishan Centre	100	0	0
KDF – Ghim Moh Centre (HD)	88	0	0
KDF – Ghim Moh Centre (PD)	0	0	0
KDF – Kreta Ayer Centre (HD)	77	0	0
Kwan Im Thong Hood Cho Temple - NKF Dialysis Centre (Kolam Ayer)	136	0	0
Kwan Im Thong Hood Cho Temple - NKF Dialysis Centre (Simei)	154	0	0
Le Champ - NKF Dialysis Centre (Blk 639 Yishun St 61)	110	0	0
Leong Hwa Chan Si Temple - NKF Dialysis Centre (Teck Whye)	105	0	0
New Creation Church - NKF Dialysis Centre	91	0	0
NKF Bukit Panjang Dialysis Centre	93	0	0
NKF Dialysis Centre (Blk 365 Woodlands II)	107	0	0
NKF Hougang Punggol Dialysis Centre	113	0	0
NTUC Income - NKF Dialysis Centre (Bukit Batok)	88	0	0
NTUC/Singapore Pools - NKF Dialysis Centre (Tampines)	130	0	0
Pei Hwa Foundation - NKF Dialysis Centre (Ang Mo Kio)	120	0	0
Peoples' Dialysis Centre	4	0	0
Queenstown - NKF Dialysis Centre	80	0	0
SAF - NKF Dialysis Centre (Clementi)	111	0	0
SAF - NKF Dialysis Centre (Hong Kah)	97	0	0
Sakyadhita -NKF Dialysis Centre (Upper Boon Keng)	100	0	0
SCAL - NKF Dialysis Centre (Yishun)	72	0	0
Sheng Hong Temple - NKF Dialysis Centre (Jurong West)	113	0	0
SIA - NKF Dialysis Centre (Toa Payoh)	79	0	0

Singapore Buddhist Welfare Services - NKF Dialysis Centre (Hougang)	156	0	0
Singapore Pools - NKF Dialysis Centre (Bedok)	105	0	0
Tampines Chinese Temple - NKF Dialysis Centre (Pasir Ris)	75	0	0
Tay Choon Hye - NKF Dialysis Centre (Kim Keat)	109	0	0
The Hour Glass - NKF Dialysis Centre (Admiralty)	76	0	0
The Singapore Buddhist Lodge - NKF Dialysis Centre (128 Bukit Merah View)	91	0	0
The Sirivadhanabhakdi Foundation - NKF Dialysis Centre (JW2)	94	0	0
Thong Teck Sian Tong Lian Sin Sia - NKF Dialysis Centre (Woodlands)	113	0	0
Toa Payoh Seu Teck Sean Tong - NKF Dialysis Centre (Yishun)	73	0	0
Western Digital - NKF Dialysis Centre (Ang Mo Kio)	143	0	0
Woh Hup - NKF Dialysis Centre (Ghim Moh)	108	0	0
Wong Sui Ha Edna - NKF Dialysis Centre	128	0	0
Sub-total	**3807**	**0**	**0**
Private clinics and dialysis centres	**HD**	**PD**	**Transplant**
Advance Dialysis Services Pte Ltd	19	0	0
Advance Renal Care (Kovan)	8	0	0
Advance Renal Care (Novena)	8	0	0
Aegis Dialysis Centre	8	0	0
Asia Renal Care Mt Elizabeth Pte Ltd	25	0	0
Arca (Farrer Park) Dialysis Pte Ltd	19	0	0
Asia Kidney Dialysis Centre (Bedok)	42	0	0
Asia Kidney Dialysis Centre (Jurong)	18	0	0
Asia Kidney Dialysis Centre (Tampines Blk 139)	6	0	0
Asia Kidney Dialysis Centre (Tampines Blk 484)	58	0	0
Asia Kidney Dialysis Centre (Teck Whye)	31	0	0
Asia Kidney Dialysis Centre (Toa Payoh)	41	0	0
B. Braun Dialysis Centre (East Coast)	23	0	0
B.Braun Dialysis Centre (Ang Mo Kio)	0	0	0
Centre for Kidney Disease Pte Ltd (Lucky Plaza)	0	0	42
Complex Medical Centre (Changi)	7	0	0
Econ Advance Renal Care (Bedok)	10	0	0
Econ Advance Renal Care (Yung Kuang)	9	0	0
Fresenius Medical Care (Teck Whye) Dialysis Clinic	44	0	0
Fresenius Medical Care Ang Mo Kio Dialysis Clinic (Blk 422)	48	0	0
Fresenius Medical Care Ang Mo Kio Dialysis Clinic (Blk 443)	41	0	0
Fresenius Medical Care Bedok North Dialysis Clinic (Blk 527)	25	0	0
Fresenius Medical Care Bedok Reservoir Dialysis Clinic (Blk 744)	55	0	0
Fresenius Medical Care Bukit Batok Dialysis Clinic (Blk 213)	38	0	0
Fresenius Medical Care Bukit Merah Dialysis Clinic (Blk 161)	57	0	0

Fresenius Medical Care Clementi Dialysis Clinic	34	0	0
Fresenius Medical Care Hougang Dialysis Clinic (Blk 620)	44	0	0
Fresenius Medical Care Jurong Boon Lay Dialysis Clinic (Blk 353)	28	0	0
Fresenius Medical Care Jurong East Central Dialysis Clinic (Blk 104)	56	0	0
Fresenius Medical Care Jurong East Dialysis Clinic (Blk 326)	44	0	0
Fresenius Medical Care Katong Dialysis Clinic	39	0	0
Fresenius Medical Care Kembangan Dialysis Clinic	48	0	0
Fresenius Medical Care Khatib Dialysis Clinic	20	0	0
Fresenius Medical Care Kovan Dialysis Clinic	51	0	0
Fresenius Medical Care Lucky Plaza Dialysis Clinic	4	1	0
Fresenius Medical Care Marsiling Dialysis Clinic	44	0	0
Fresenius Medical Care Napier Dialysis Clinic	25	2	0
Fresenius Medical Care Serangoon Dialysis Clinic	57	0	0
Fresenius Medical Care Tampines Dialysis Clinic (Blk 107)	48	0	0
Fresenius Medical Care Tanglin Dialysis Clinic	32	0	0
Fresenius Medical Care Toa Payoh Dialysis Clinic (Blk 92)	36	0	0
Fresenius Medical Care Upper Serangoon Dialysis Clinic	0	0	0
Fresenius Medical Care Whampoa Dialysis Clinic	41	0	0
Fresenius Medical Care Yishun Dialysis Clinic (Blk 236)	43	0	0
Fresenius Medical Care Yishun Ring Dialysis Clinic	32	0	0
Grace Lee Renal and Medical Clinic Pte Ltd	0	0	9
Immanuel Dialysis Centre (Mayflower) Pte Ltd	11	0	0
Immanuel Dialysis Centre Pte Ltd (Ang Mo Kio)	25	0	0
Immanuel Dialysis Centre Pte Ltd (Mt Alvernia)	30	0	0
Immanuel Dialysis Centre Pte Ltd (Woodlands)	25	0	0
Immanuel Dialysis Centre Pte Ltd (Yishun)	16	0	0
Kidney & Medical Centre	0	0	5
Kidneycare Dialysis Centre @ Pasir Ris	50	0	0
Kidneycare Dialysis Centre @ West Coast	12	0	0
Kidneycare Dialysis Centre @ Yishun	18	0	0
Ku Kidney & Medical Centre	0	0	16
Pacific Advance Renal Care (Choa Chu Kang)	13	0	0
Pacific Advance Renal Care (Fajar)	24	0	0
Pacific Advance Renal Care (Seng Kang)	35	0	0
Pacific Advance Renal Care Pte Ltd (Punggol Way)	36	0	0
Pacific Advance Renal Care Pte Ltd (Tampines)	29	0	0
Pacific Advance Renal Care Pte Ltd (Woodlands)	39	0	0
Raffles Dialysis Centre	3	0	0
Raffles Hospital	0	0	3
Renal Health Pte Ltd	62	0	0
Renal Life (Alexandra) Dialysis Centre Pte Ltd	13	0	0

Renal Life (Hougang) Dialysis Centre Pte Ltd	19	0	0
Renal Life (W) Dialysis Centre Pte Ltd (Blk 207 Bukit Batok)	29	0	0
Renal Life Dialysis Centre Pte Ltd (Blk 463 Jurong West)	26	0	0
Renal Life (Pioneer) Dialysis Centre Pte Ltd	35	0	0
Renalteam Dialysis Centre - Ang Mo Kio	30	0	0
Renalteam Dialysis Centre - Bedok	40	0	0
Renalteam Dialysis Centre - Bukit Merah	30	0	0
Renalteam Dialysis Centre - Jurong East	39	0	0
Renalteam Dialysis Centre - Ren Ci Community Hospital	40	0	0
Renalteam Dialysis Centre - Tampines	46	0	0
Renalteam Dialysis Centre - Woodlands	0	0	0
Renalteam Dialysis Centre – Woodlands Peak	36	0	0
Renalteam Dialysis Centre - Yishun	12	0	0
Roger Kidney Clinic	0	0	4
SH Tan Kidney & Medical Clinic	0	0	1
Stephew Chew Centre For Kidney Disease And Hypertension (MAH)	0	0	20
Stephew Chew Centre For Kidney Disease And Hypertension (MEH)	0	0	4
TG Ng Kidney & Medical Centre	0	0	1
TAL Dialysis Clementi	17	0	0
The Kidney Clinic Pte Ltd	0	0	12
The Singapore Clinic For Kidney Diseases	0	0	3
Wu Nephrology & Medical Clinic (Wu Medical Clinic Pte Ltd)	0	0	32
Sub-total	**2206**	**3**	**152**
Grand total	**6113**	**894**	**1560**

5.2 Incidence of CKD5

The incidence rate in each year was computed 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. These included all patients (i) initiating renal replacement therapy since 2008, (ii) presenting with serum creatinine ≥10 mg/dl or ≥880 μmol/L in 2008 and 2009, or (iii) presenting with serum creatinine ≥500 μmol/L or eGFR <15 ml/min/1.73m^2 since 2010. Patients were categorized into 10-year age groups and age standardization was done using the direct method with the Segi World population as the standardization weights.

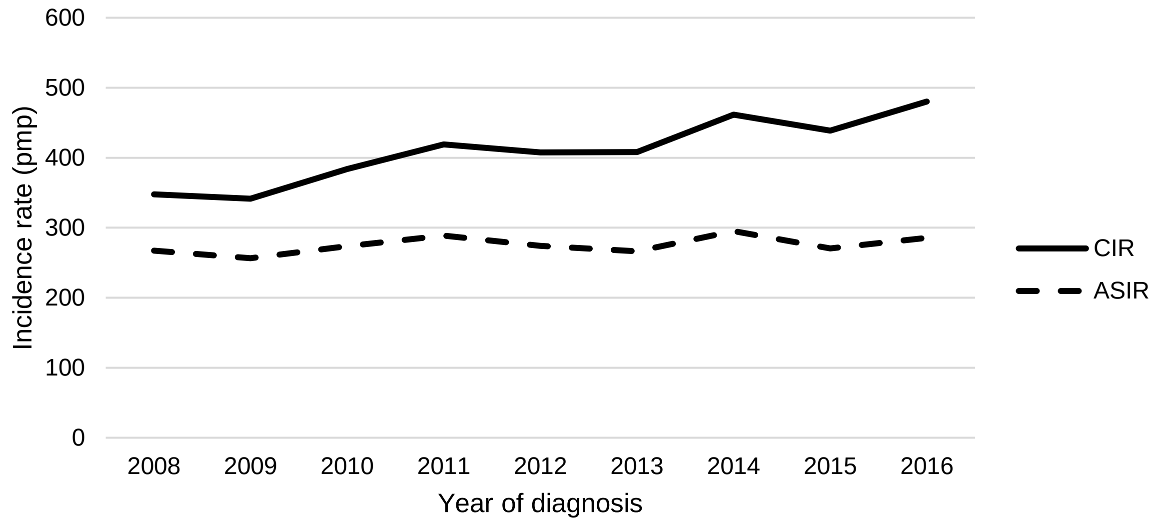
As the SRR monitors the patient's eGFR readings for at least six months before accepting a case as CKD5, the yearly number of new CKD5 patients typically takes two years to stabilize. Hence, all statistics related to new CKD5 patients for 2017 are not shown in this section.

The number of new patients diagnosed with CKD5 increased from 1,267 in 2008 to 1,889 in 2016 (Table 5.2.1 and Figure 5.2.1). Correspondingly, the CIR increased significantly from 347.8 pmp in 2008 to 480.2 pmp in 2016 ($p<0.001$). However, the ASIR remained relatively stable, ranging between 255 pmp and 296 pmp during this period. These imply that the rise in new patients 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
2008	1267	347.8	267.4
2009	1275	341.5	256.5
2010	1448	383.9	273.8
2011	1587	418.8	288.9
2012	1557	407.8	274.0
2013	1569	408.1	266.5
2014	1786	461.4	295.2
2015	1712	438.7	270.4
2016	1889	480.2	285.7
P for trend	-	<0.001	0.165

Figure 5.2.1: Incidence rate (pmp) of CKD5



The majority of the new CKD5 patients were aged 50 years or older (Table 5.2.2). In 2016, almost 9 in 10 of the new CKD5 patients were in this age band.

The median age at diagnosis of CKD5 fluctuated between 62 to 68 years over the decade (Figure 5.2.2a).

The CIR of CKD5 remained stable over the years for all age groups except for those aged 80 years or above, where there was a rise from 2008 to 2011, a drop from 2012 to 2014 and a rise again from 2015 to 2016 (Figure 5.2.2b). The significant rise in overall CIR was mainly driven by the significant rise in CIR among the 40-49 age group (p=0.031).

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
2008	6	0.5	6.4	14	1.1	28.7	47	3.7	78.7	143	11.3	225.1
2009	9	0.7	9.7	19	1.5	36.8	44	3.5	71.6	118	9.3	185.7
2010	5	0.3	5.4	12	0.8	23.1	51	3.5	82.4	161	11.1	254.3
2011	7	0.4	7.8	19	1.2	36.7	55	3.5	89.6	131	8.3	207.7
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	23	1.3	43.4	51	2.9	85.8	193	10.8	309.0
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	38	2.0	64.7	175	9.3	284.7
P for trend	-	-	0.482	-	-	0.779	-	-	0.863	-	-	0.031
Year of diagnosis	**Age 50-59**			**Age 60-69**			**Age 70-79**			**Age 80+**		
	Number	**%**	**CIR**	**Number**	**%**	**CIR**	**Number**	**%**	**CIR**	**Number**	**%**	**CIR**
2008	307	24.2	592.0	348	27.5	1297.1	271	21.4	1933.0	131	10.3	2172.5
2009	261	20.5	485.7	336	26.4	1175.2	310	24.3	2080.5	178	14.0	2742.7
2010	333	23.0	603.5	343	23.7	1131.3	339	23.4	2149.7	204	14.1	2948.0
2011	323	20.4	568.1	394	24.8	1229.3	398	25.1	2384.7	260	16.4	3551.9
2012	317	20.4	544.5	380	24.4	1108.5	348	22.4	2023.3	273	17.5	3518.0
2013	366	23.3	616.3	413	26.3	1122.0	344	21.9	1953.4	222	14.1	2704.0
2014	436	24.4	722.0	488	27.3	1242.7	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	260	15.2	2782.3
2016	351	18.6	570.6	532	28.2	1182.6	415	22.0	2164.3	356	18.8	3640.1
P for trend	-	-	0.213	-	-	0.314	-	-	0.908	-	-	0.270

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

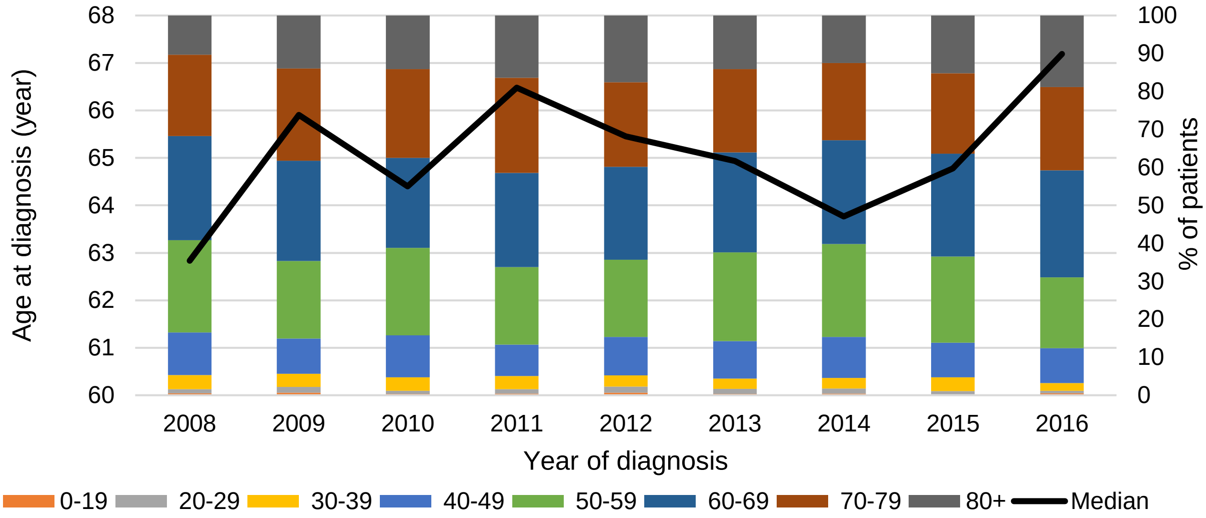
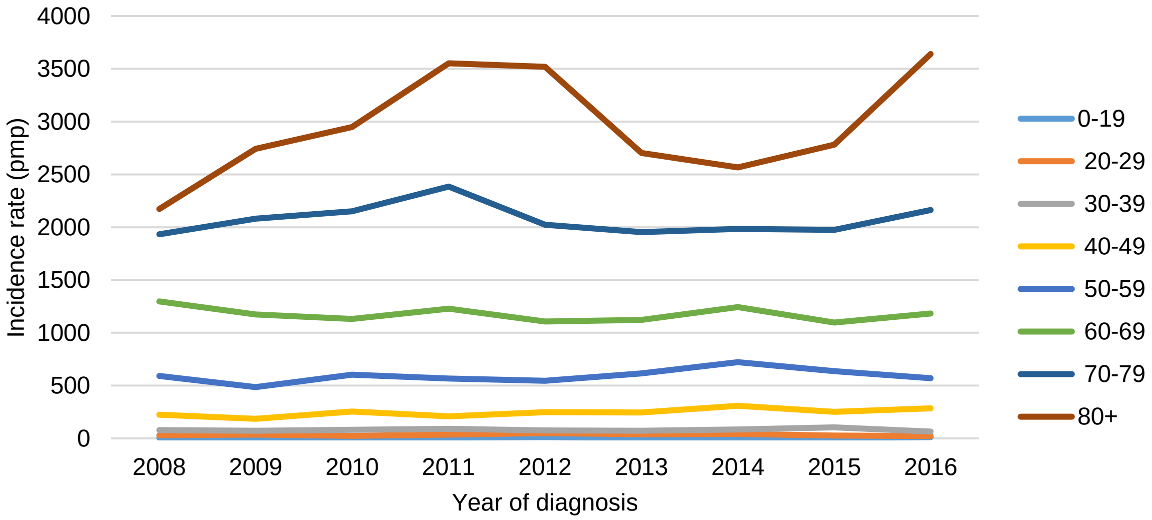
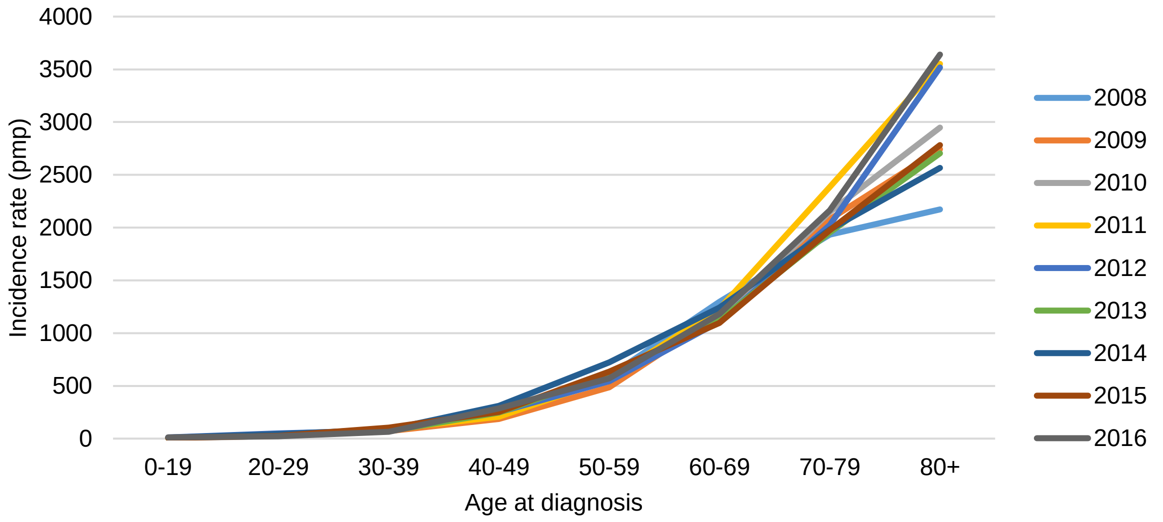


Figure 5.2.2b: Age-specific incidence rate (pmp) of CKD5 across years



The CIR of CKD5 increased with age, with a steep rise starting from age 50 years onwards (Figure 5.2.3).

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

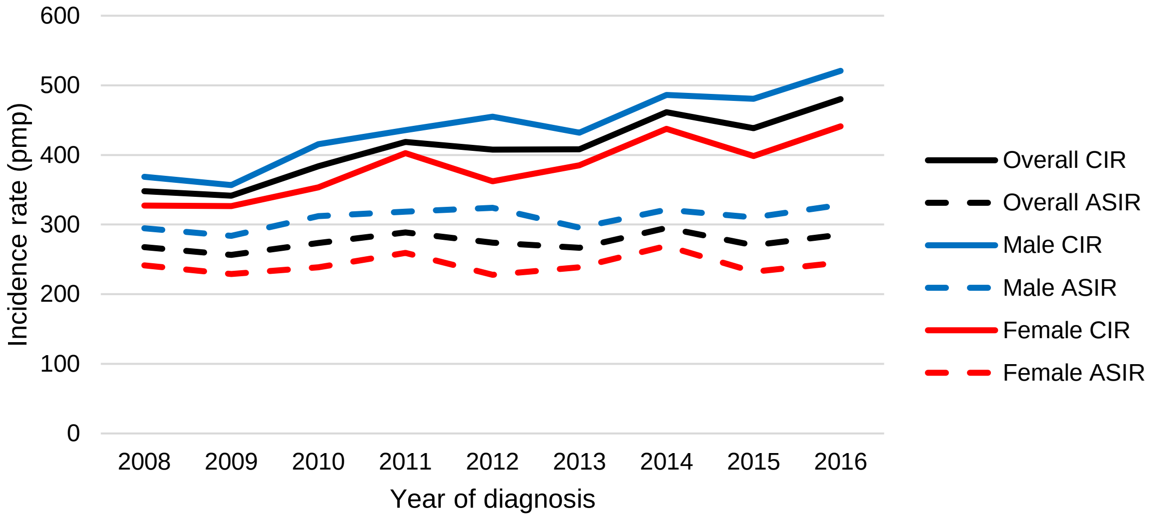


The ASIR of CKD5 were consistently higher among men than women across the years (Table 5.2.3 and Figure 5.2.4). In 2016, the ASIR was 328.3 pmp and 245.7 pmp for men and women respectively. The ASIR for both genders remained stable over the years.

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

Male				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2008	665	52.5	368.9	294.5
2009	658	51.6	356.7	283.8
2010	773	53.4	415.3	312.2
2011	814	51.3	435.7	318.6
2012	855	54.9	454.8	323.9
2013	817	52.1	432.0	295.4
2014	925	51.8	486.2	321.2
2015	921	53.8	480.5	310.2
2016	1005	53.2	520.9	328.3
P for trend	-	-	<0.001	0.073
Female				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2008	602	47.5	327.2	241.4
2009	617	48.4	326.6	229.2
2010	675	46.6	353.3	238.6
2011	773	48.7	402.4	259.2
2012	702	45.1	362.2	227.9
2013	752	47.9	385.0	238.8
2014	861	48.2	437.4	269.3
2015	791	46.2	398.3	232.3
2016	884	46.8	441.1	245.7
P for trend	-	-	0.002	0.567

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



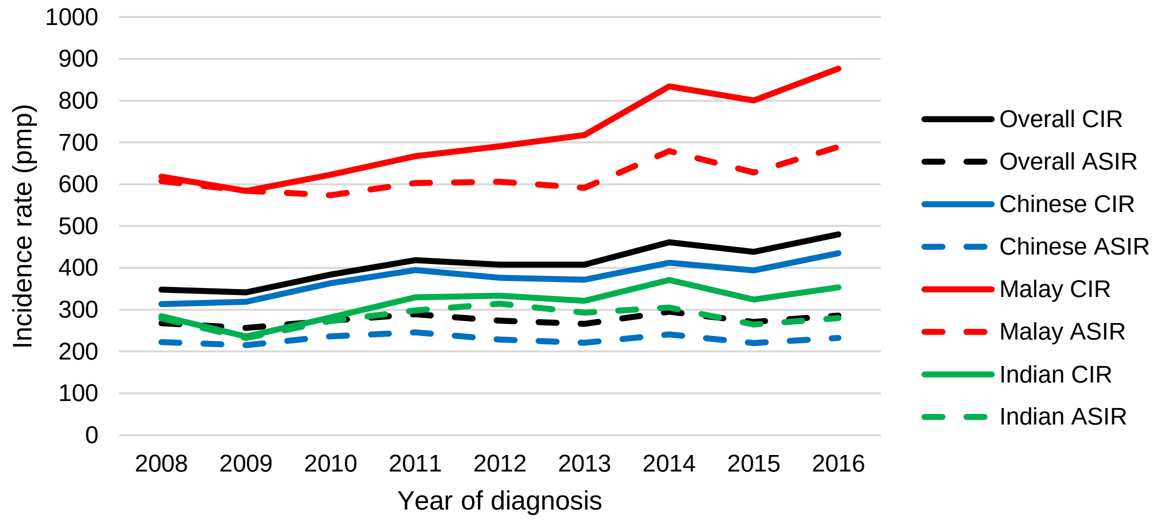
The ASIR of CKD5 were consistently higher among the Malays than the Chinese and Indians across the years (Table 5.2.4 and Figure 5.2.5). In 2016, the ASIR was 232.5 pmp, 689.4 pmp and 279.9 pmp for the Chinese, Malays and Indians respectively. While the ASIR for the Malays increased significantly over the years (p=0.023), the ASIR for the Chinese and Indians remained relatively stable.

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

Chinese				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2008	853	67.3	313.4	222.8
2009	883	69.3	318.7	215.2
2010	1015	70.1	363.3	236.0
2011	1109	69.9	394.9	245.8
2012	1065	68.4	376.1	228.8
2013	1062	67.7	372.1	221.4
2014	1186	66.4	412.6	240.6
2015	1143	66.8	394.1	220.2
2016	1272	67.3	435.1	232.5
P for trend	-	-	0.001	0.647
Malay				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2008	306	24.2	617.9	607.2
2009	292	22.9	584.0	584.4
2010	314	21.7	623.0	573.8
2011	338	21.3	667.5	602.9
2012	352	22.6	691.0	606.0
2013	368	23.5	717.8	591.4
2014	431	24.1	834.2	679.7
2015	417	24.4	800.5	628.1
2016	461	24.4	876.6	689.4
P for trend	-	-	<0.001	0.023

Indian				
Year of diagnosis	**Number**	**%**	**CIR**	**ASIR**
2008	92	7.3	284.6	279.4
2009	81	6.4	235.9	232.3
2010	98	6.8	281.7	272.8
2011	115	7.2	329.7	298.0
2012	117	7.5	333.3	314.5
2013	113	7.2	321.5	293.2
2014	131	7.3	371.1	305.2
2015	115	6.7	324.0	264.8
2016	126	6.7	353.1	279.9
P for trend	-	-	0.014	0.422

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



5.3 Incidence of ever-started dialysis

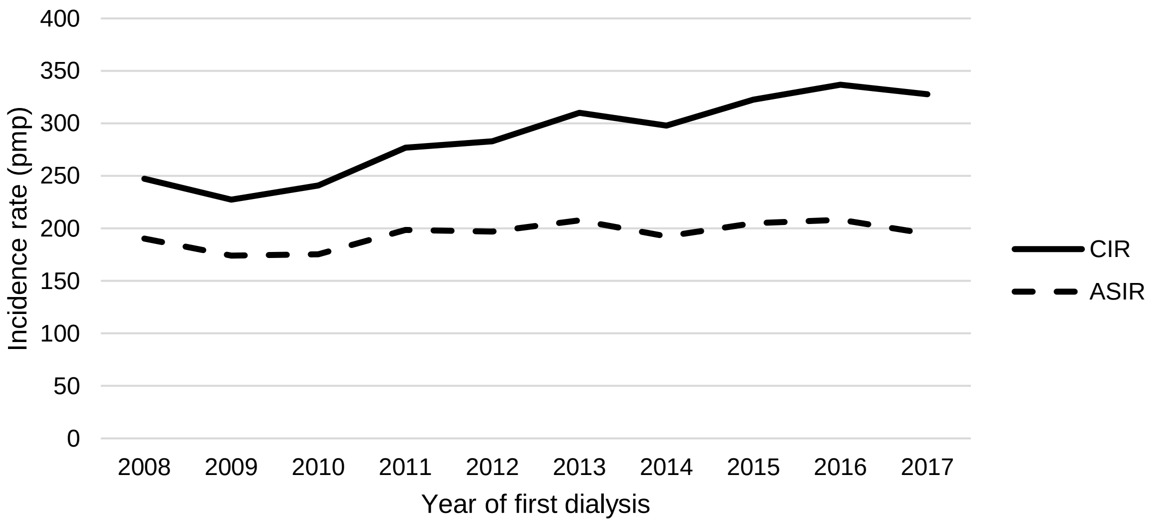
The incidence rate in each year was computed by taking the number of new patients who ever-started on dialysis in a year, divided by the number of Singapore residents in the same year. The count was based on the date of first dialysis and modality was based on the first dialysis. Patients were categorized into 10-year age groups and age standardization was done using the direct method with the Segi World population as the standardization weights.

Similar to the incidence trend in CKD5 (Table 5.2.1 and Figure 5.2.1), the number of new patients who initiated dialysis increased from 901 in 2008 to 1,300 in 2017 (Table 5.3.1 and Figure 5.3.1). Correspondingly, the CIR increased significantly from 247.4 pmp in 2008 to 327.8 pmp in 2017 ($p<0.001$). There was a marginally significant rise in ASIR from 190.4 pmp in 2008 to 194.9 pmp in 2017 ($p=0.045$).

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

Year of first dialysis	Number	CIR	ASIR
2008	901	247.4	190.4
2009	849	227.4	174.1
2010	909	241.0	175.4
2011	1049	276.8	198.5
2012	1080	282.9	196.9
2013	1192	310.1	207.7
2014	1153	297.9	192.6
2015	1259	322.6	205.0
2016	1325	336.8	208.2
2017	1300	327.8	194.9
P for trend	-	<0.001	0.045

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



The majority of the new ever-started dialysis patients were aged between 50 to 79 years. In 2017, close to 80% of the new ever-started dialysis patients were in this age band (Table 5.3.2).

The median age at first dialysis increased from 61.2 years in 2008 to 64.6 years in 2017 (Figure 5.3.2a).

The CIR of ever-started dialysis increased significantly for those aged between 40 to 49 years (p=0.033) and those aged 80 years or above (p=0.030) (Figure 5.3.2b). This corresponded to the significant rise in CIR of CKD5 for the patients in the 40-49 age group (Table 5.2.2). However, the rise in CIR of CKD5 was not significant for patients in the 80+ age group, implying that more elderly patients initiated dialysis upon diagnosis of CKD5 over the years.

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
2008	4	0.4	4.3	11	1.2	22.5	46	5.1	77.0	115	12.8	181.0
2009	7	0.8	7.5	16	1.9	31.0	38	4.5	61.8	98	11.5	154.2
2010	4	0.4	4.4	11	1.2	21.2	37	4.1	59.8	109	12.0	172.2
2011	7	0.7	7.8	17	1.6	32.8	42	4.0	68.4	114	10.9	180.8
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	19	1.6	35.9	38	3.3	63.9	139	12.1	222.6
2015	5	0.4	5.9	16	1.3	29.9	41	3.3	69.3	139	11.0	224.1
2016	9	0.7	10.8	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	114	8.8	185.4
P for trend	-	-	0.946	-	-	0.716	-	-	0.464	-	-	0.033
Year of first dialysis	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2008	240	26.6	462.8	264	29.3	984.0	178	19.8	1269.6	43	4.8	713.1
2009	198	23.3	368.4	280	33.0	979.4	166	19.6	1114.1	46	5.4	708.8
2010	253	27.8	458.5	250	27.5	824.5	184	20.2	1166.8	61	6.7	881.5
2011	267	25.5	469.6	301	28.7	939.2	226	21.5	1354.1	75	7.1	1024.6
2012	271	25.1	465.5	302	28.0	881.0	230	21.3	1337.2	91	8.4	1172.7
2013	319	26.8	537.1	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	18.6	1168.7	93	8.1	1065.4
2015	319	25.3	522.8	397	31.5	938.7	243	19.3	1321.8	99	7.9	1059.4
2016	335	25.3	544.5	430	32.5	955.8	268	20.2	1397.6	91	6.9	930.5
2017	286	22.0	465.4	433	33.3	927.9	294	22.6	1390.4	115	8.8	1135.5
P for trend	-	-	0.054	-	-	0.773	-	-	0.073	-	-	0.030

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

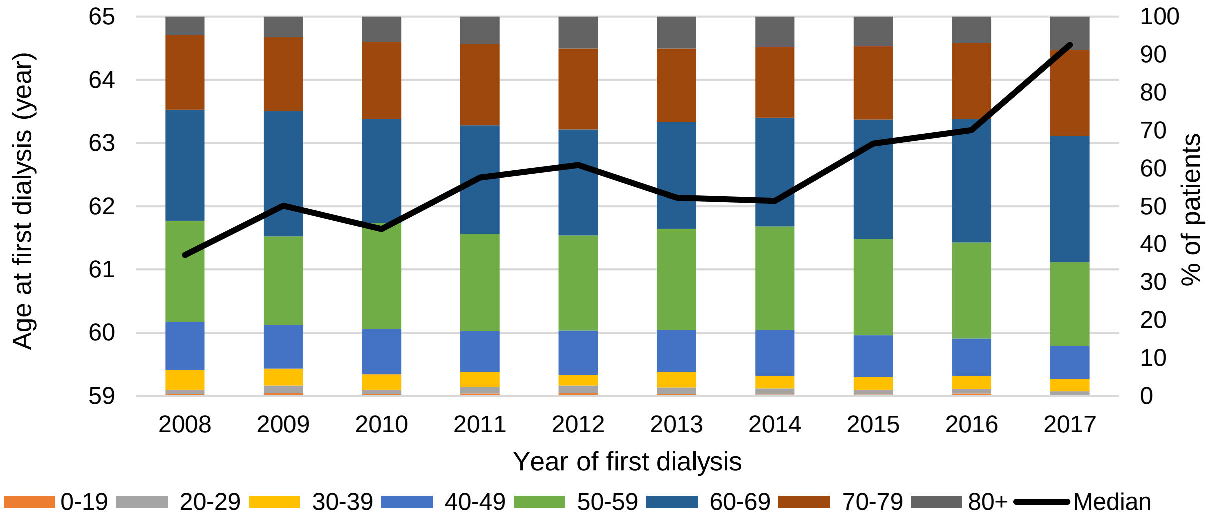
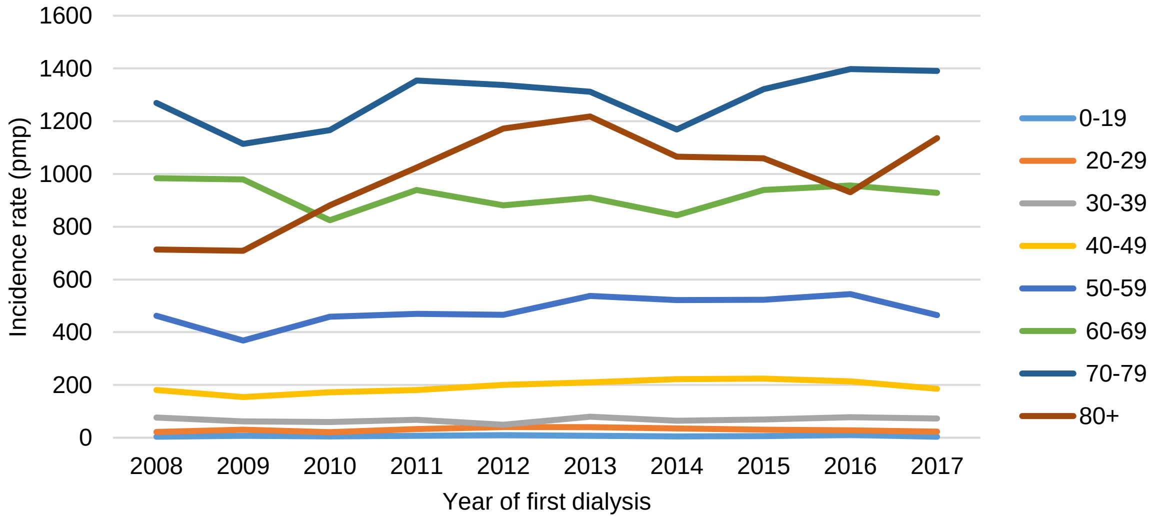
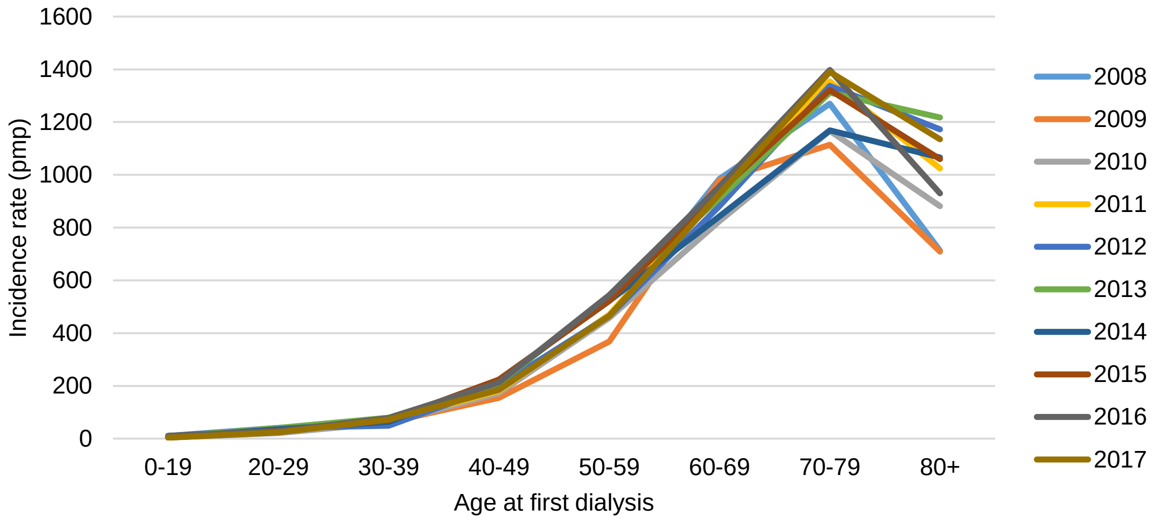


Figure 5.3.2b: Age-specific incidence rate (pmp) of ever-started dialysis across years



The CIR of ever-started dialysis increased with age, with a steep rise from age 50 to 79 years (Figure 5.3.3). However, a steep decline was observed from age 80 years onwards. Reasons may include elderly patients refusing dialysis or passing away before their first planned dialysis.

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



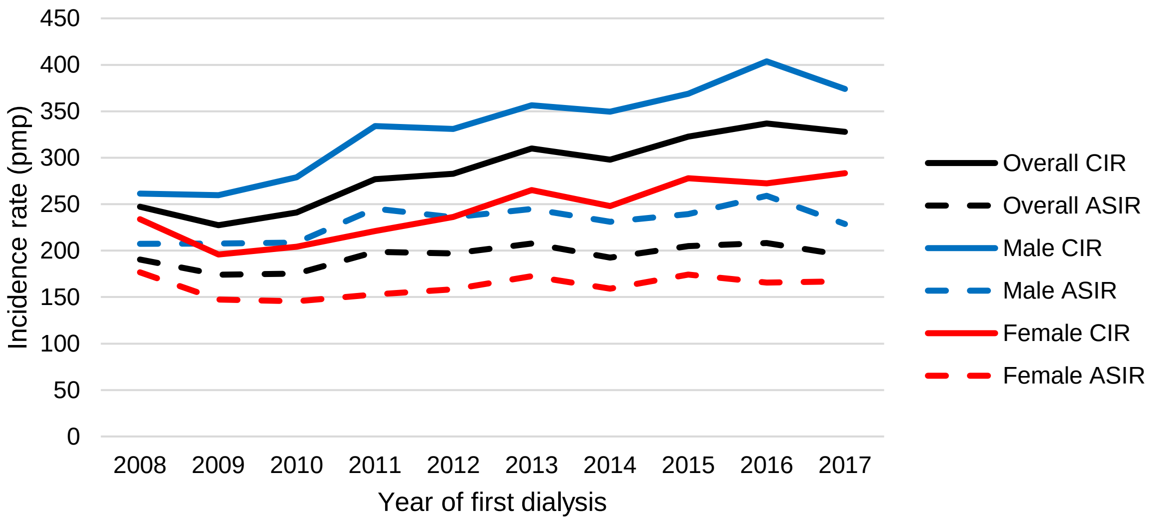
The ASIR of ever-started dialysis were consistently higher among men than women across the years (Table 5.3.3 and Figure 5.3.4). In 2017, the ASIR was 228.6 pmp and 166.9 pmp for men and women respectively. While the ASIR for men increased significantly over the years (p=0.025), the ASIR for women remained relatively stable.

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

Male				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	471	52.3	261.2	207.4
2009	479	56.4	259.7	207.8
2010	519	57.1	278.9	208.9
2011	624	59.5	334.0	245.2
2012	622	57.6	330.9	235.8
2013	674	56.5	356.4	245.0
2014	665	57.7	349.6	231.2
2015	707	56.2	368.9	239.5
2016	779	58.8	403.7	259.0
2017	727	55.9	374.1	228.6
P for trend	-	-	<0.001	0.025

Year of first dialysis	Female			
	Number	%	CIR	ASIR
2008	430	47.7	233.7	176.7
2009	370	43.6	195.9	147.3
2010	390	42.9	204.1	145.5
2011	425	40.5	221.2	152.8
2012	458	42.4	236.3	158.5
2013	518	43.5	265.2	172.5
2014	488	42.3	247.9	159.0
2015	552	43.8	277.9	174.3
2016	546	41.2	272.5	165.8
2017	573	44.1	283.3	166.9
P for trend	-	-	0.002	0.283

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

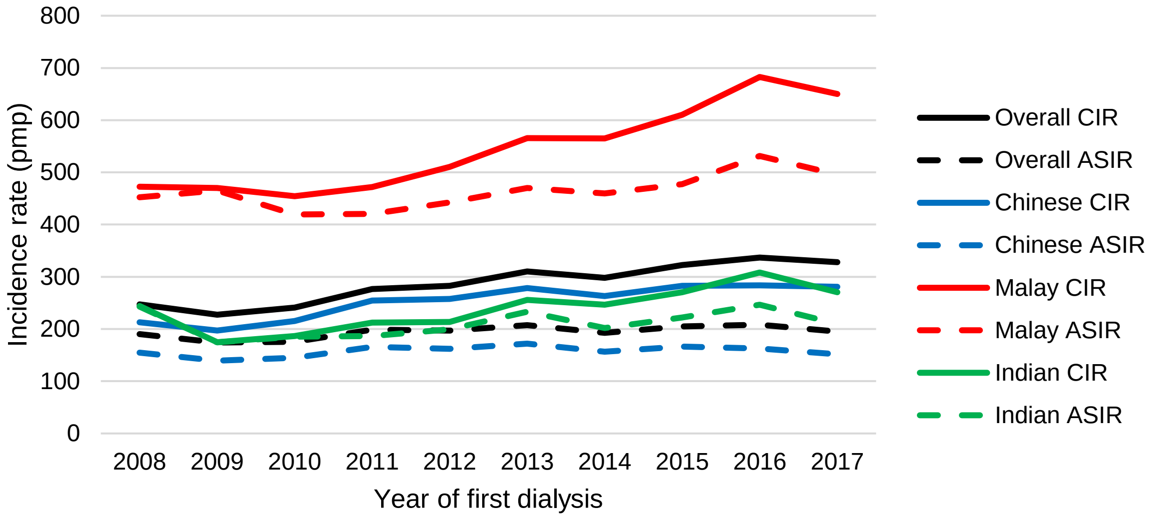


The ASIR of ever-started dialysis were consistently higher among the Malays than the Chinese and Indians across the years (Table 5.3.4 and Figure 5.3.5). In 2017, the ASIR was 151.5 pmp, 495.8 pmp and 209.8 pmp for the Chinese, Malays and Indians respectively. While the ASIR for the Malays increased significantly over the years (p=0.025), the ASIR for the Chinese and Indians remained relatively stable.

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

Chinese				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	580	64.4	213.1	154.9
2009	546	64.3	197.1	139.4
2010	602	66.2	215.5	144.9
2011	715	68.2	254.6	165.6
2012	729	67.5	257.5	162.0
2013	795	66.7	278.6	172.0
2014	757	65.7	263.4	156.6
2015	820	65.1	282.8	166.3
2016	829	62.6	283.6	162.4
2017	828	63.7	280.8	151.5
P for trend	-	-	0.001	0.244
Malay				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	234	26.0	472.5	452.1
2009	235	27.7	470.0	465.0
2010	229	25.2	454.4	419.3
2011	239	22.8	472.0	420.5
2012	260	24.1	510.4	442.3
2013	290	24.3	565.6	470.3
2014	292	25.3	565.2	459.4
2015	318	25.3	610.5	477.3
2016	359	27.1	682.7	531.4
2017	345	26.5	650.1	495.8
P for trend	-	-	<0.001	0.025
Indian				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	79	8.8	244.4	243.2
2009	60	7.1	174.7	174.5
2010	65	7.2	186.8	185.2
2011	74	7.1	212.2	186.8
2012	75	6.9	213.7	199.2
2013	90	7.6	256.0	233.0
2014	87	7.5	246.4	201.8
2015	96	7.6	270.5	222.2
2016	110	8.3	308.2	246.5
2017	97	7.5	270.3	209.8
P for trend	-	-	0.011	0.299

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



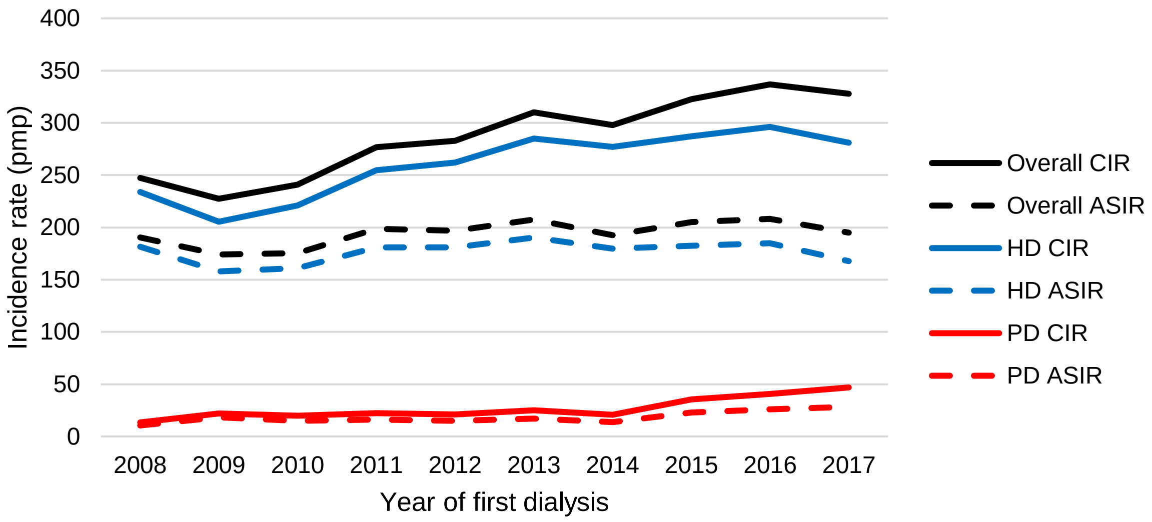
The ASIR of ever-started dialysis were consistently higher among HD than PD across the years (Table 5.3.5 and Figure 5.3.6). In 2017, the ASIR was 167.8 pmp and 28.3 pmp for HD and PD respectively. While the ASIR for PD increased significantly over the years (p=0.006), the ASIR for HD remained relatively stable.

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

	HD			
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	852	94.6	233.9	181.5
2009	767	90.3	205.4	157.9
2010	834	91.7	221.1	160.9
2011	965	92.0	254.7	181.0
2012	1000	92.6	261.9	181.0
2013	1096	91.9	285.1	190.3
2014	1072	93.0	276.9	179.8
2015	1121	89.0	287.2	182.5
2016	1165	87.9	296.2	185.0
2017	1114	85.7	280.9	167.8
P for trend	-	-	0.001	0.379

PD				
Year of first dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	49	5.4	13.5	10.5
2009	82	9.7	22.0	18.2
2010	75	8.3	19.9	14.9
2011	84	8.0	22.2	16.2
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	160	12.1	40.7	25.8
2017	186	14.3	46.9	28.3
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

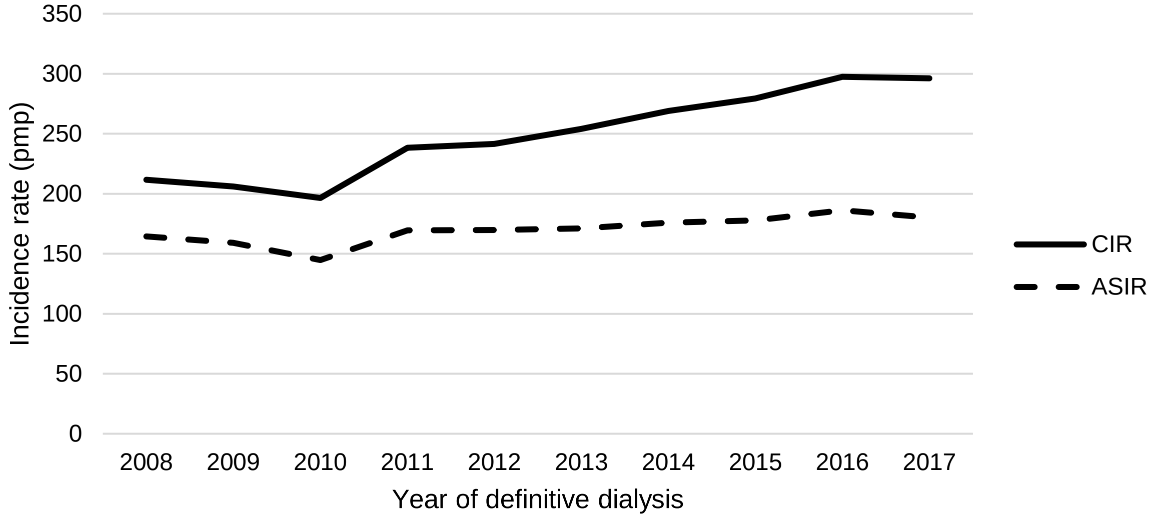
The incidence rate in each year was computed by taking the number of new patients who survived >90 days after initiation of dialysis in a year, divided by the number of Singapore residents in the same year. The count was based on the 91st day from the date of first dialysis. If there was a dialysis record on the 91st day from the first dialysis, the modality on the 91st day was taken. Otherwise, the modality on the closest date before the 91st day was taken. However, if there was no dialysis record between the first dialysis and the 91st day, the modality of the first dialysis was taken. As some patients with pre-existing co-morbidities did not survive past three months from the first dialysis, those on definitive dialysis is a relatively more stable subset of the CKD5 cohort and ever-started dialysis cohort. Patients were categorized into 10-year age groups and age standardization was done using the direct method with the Segi World population as the standardization weights.

Mirroring the incidence trend of ever-started dialysis (Table 5.3.1 and Figure 5.3.1), the number of new patients on definitive dialysis increased from 771 in 2008 to 1,175 in 2017 (Table 5.4.1 and Figure 5.4.1). Correspondingly, the CIR increased significantly from 211.7 pmp in 2008 to 296.3 pmp in 2017 (p<0.001). The rise in ASIR from 164.5 pmp in 2008 to 180.2 pmp in 2017 was also significant (p=0.007).

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

Year of definitive dialysis	Number	CIR	ASIR
2008	771	211.7	164.5
2009	769	206.0	159.0
2010	741	196.5	144.7
2011	903	238.3	169.6
2012	922	241.5	169.8
2013	977	254.1	171.0
2014	1041	268.9	175.8
2015	1090	279.3	177.7
2016	1170	297.4	186.2
2017	1175	296.3	180.2
P for trend	-	<0.001	0.007

Figure 5.4.1: Incidence rate (pmp) of definitive dialysis



The majority of the new definitive dialysis patients were aged 50 to 79 years. In 2017, close to 80% of the new definitive dialysis patients were in this age band (Table 5.4.2).

The median age at definitive dialysis increased from 60.6 years in 2008 to 63.9 years in 2017 (Figure 5.4.2a).

The CIR of definitive dialysis increased significantly for those in the 40-49 (p=0.028), 50-59 (p=0.011), 70-79 (p=0.019) and 80+ age groups (p=0.034) (Figure 5.4.2b).

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
2008	3	0.4	3.2	11	1.4	22.5	50	6.5	83.7	99	12.8	155.8
2009	9	1.2	9.7	15	2.0	29.1	34	4.4	55.3	101	13.1	159.0
2010	3	0.4	3.3	12	1.6	23.1	25	3.4	40.4	83	11.2	131.1
2011	4	0.4	4.5	14	1.6	27.0	39	4.3	63.5	107	11.8	169.7
2012	10	1.1	11.3	19	2.1	36.6	29	3.1	47.6	109	11.8	173.1
2013	6	0.6	6.9	20	2.0	38.3	38	3.9	63.1	119	12.2	189.2
2014	5	0.5	5.8	19	1.8	35.9	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	7	0.6	8.5	12	1.0	21.8	39	3.3	67.2	108	9.2	175.6
P for trend	-	-	0.486	-	-	0.882	-	-	0.580	-	-	0.028
Year of definitive dialysis	**Age 50-59**			**Age 60-69**			**Age 70-79**			**Age 80+**		
	Number	**%**	**CIR**	**Number**	**%**	**CIR**	**Number**	**%**	**CIR**	**Number**	**%**	**CIR**
2008	207	26.8	399.2	236	30.6	879.6	124	16.1	884.5	41	5.3	679.9
2009	197	25.6	366.6	232	30.2	811.5	150	19.5	1006.7	31	4.0	477.7
2010	206	27.8	373.3	232	31.3	765.2	131	17.7	830.7	49	6.6	708.1
2011	242	26.8	425.6	264	29.2	823.7	178	19.7	1066.5	55	6.1	751.4
2012	227	24.6	389.9	280	30.4	816.8	191	20.7	1110.5	57	6.2	734.5
2013	277	28.4	466.4	273	27.9	741.6	170	17.4	965.4	74	7.6	901.3
2014	307	29.5	508.4	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	212	19.4	1153.2	73	6.7	781.2
2016	287	24.5	466.5	385	32.9	855.8	232	19.8	1209.9	84	7.2	858.9
2017	275	23.4	447.5	399	34.0	855.1	255	21.7	1206.0	80	6.8	789.9
P for trend	-	-	0.011	-	-	0.972	-	-	0.019	-	-	0.034

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

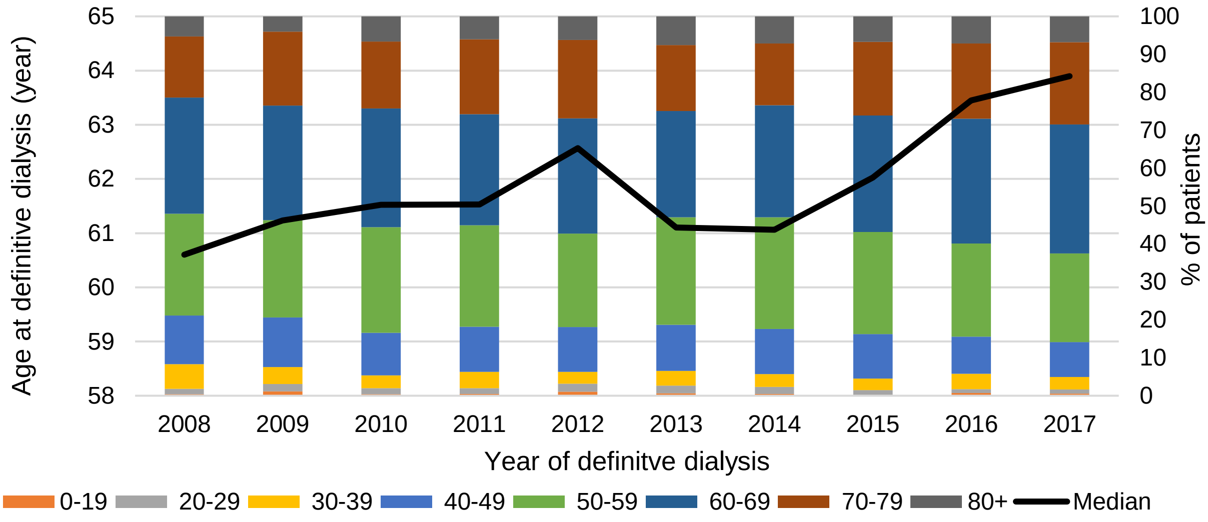
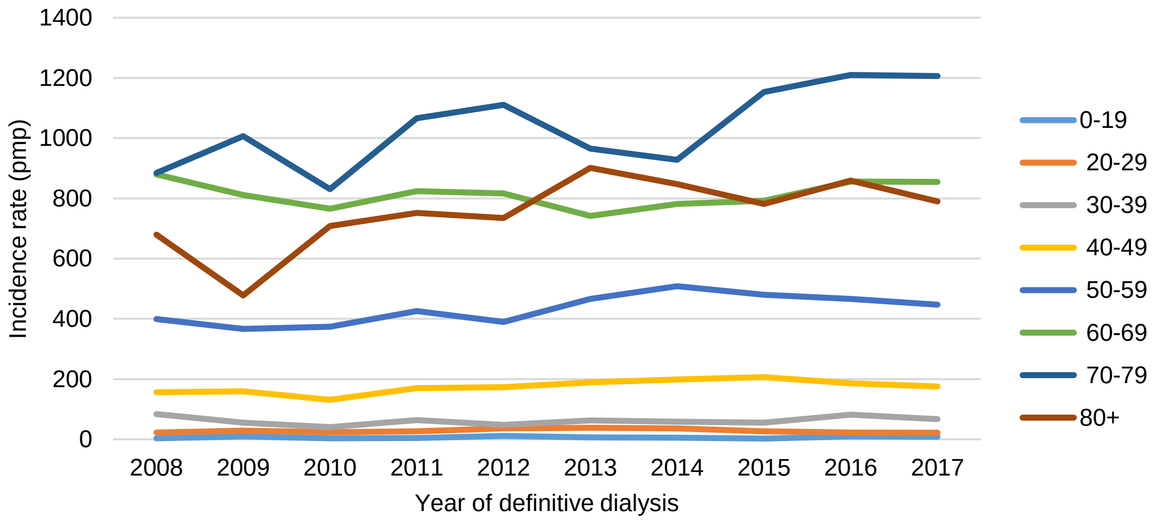
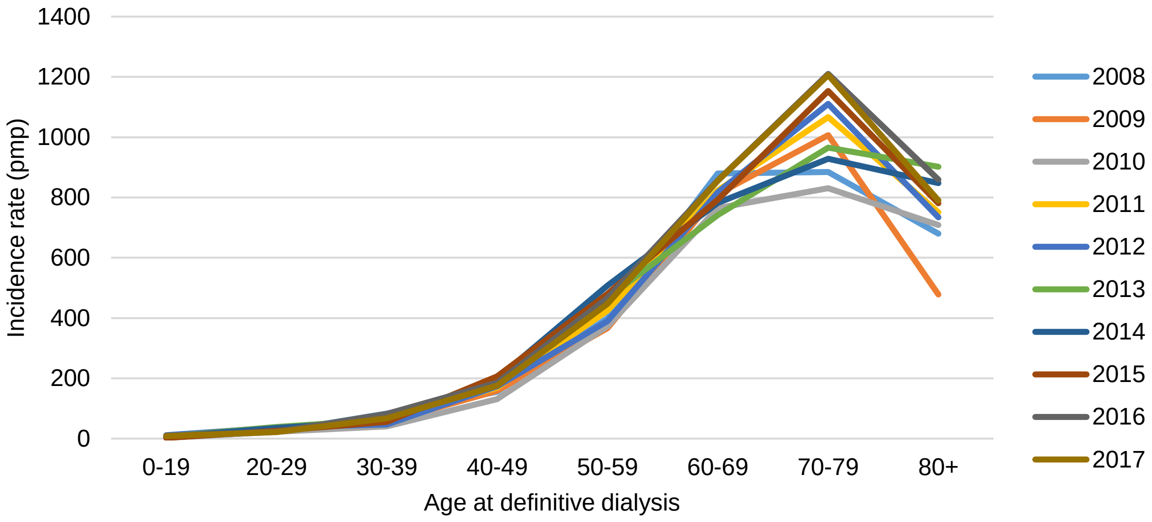


Figure 5.4.2b: Age-specific incidence rate (pmp) of definitive dialysis across years



The CIR of definitive dialysis increased with age, with a steep rise from age 50 to 79 years (Figure 5.4.3). However, a steep decline was observed from age 80 years onwards. Reasons may include elderly patients refusing dialysis or passing away before their first planned dialysis or definitive dialysis.

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



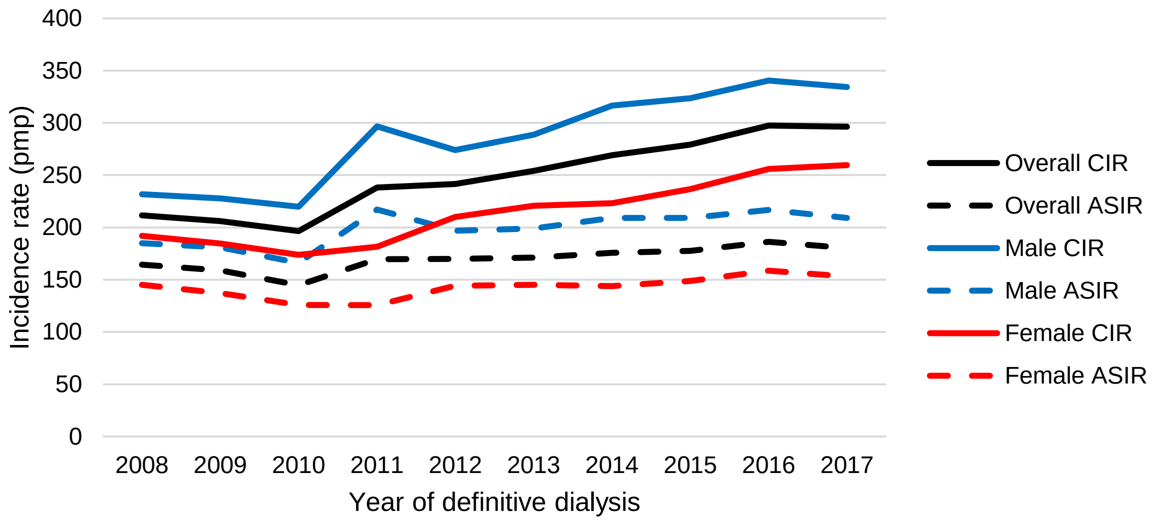
The ASIR of definitive dialysis were consistently higher among men than women across the years (Table 5.4.3 and Figure 5.4.4). In 2017, the ASIR was 209.0 pmp and 153.2 pmp for men and women respectively. The ASIR increased significantly over the years for both genders (p=0.020 for men and p=0.036 for women).

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

Male				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	418	54.2	231.8	184.9
2009	420	54.6	227.7	180.9
2010	409	55.2	219.8	166.1
2011	554	61.4	296.5	217.1
2012	515	55.9	274.0	196.8
2013	546	55.9	288.7	198.8
2014	602	57.8	316.4	209.2
2015	620	56.9	323.5	209.2
2016	657	56.2	340.5	216.6
2017	650	55.3	334.4	209.0
P for trend	-	-	<0.001	0.020

Female				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	353	45.8	191.9	145.0
2009	349	45.4	184.7	137.0
2010	332	44.8	173.8	125.7
2011	349	38.6	181.7	125.6
2012	407	44.1	210.0	144.1
2013	431	44.1	220.7	145.1
2014	439	42.2	223.0	143.8
2015	470	43.1	236.6	148.6
2016	513	43.8	256.0	158.6
2017	525	44.7	259.6	153.2
P for trend	-	-	<0.001	0.036

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

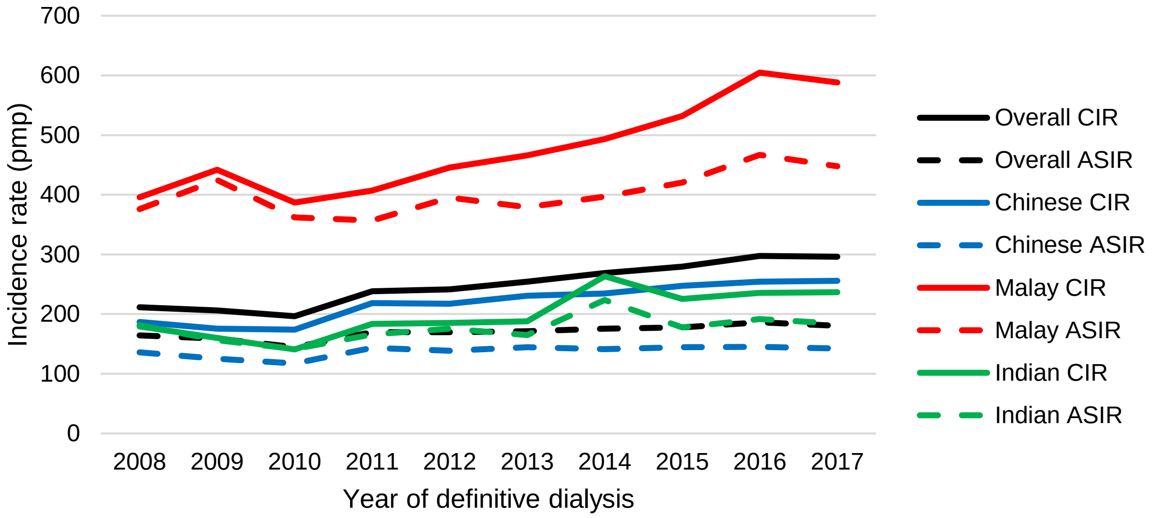


The ASIR of definitive dialysis were consistently higher among the Malays than the Chinese and Indians across the years (Table 5.4.4 and Figure 5.4.5). In 2017, the ASIR was 142.3 pmp, 447.6 pmp and 183.9 pmp for the Chinese, Malays and Indians respectively. While the ASIR for the Chinese and Malays increased significantly over the years (p=0.047 for Chinese and p=0.035 for Malays), the ASIR for the Indians was fluctuating between 141 pmp and 224 pmp.

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

Chinese				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	509	66.0	187.0	136.1
2009	486	63.2	175.4	124.9
2010	486	65.6	174.0	117.4
2011	614	68.0	218.6	143.2
2012	616	66.8	217.5	138.7
2013	658	67.3	230.6	144.6
2014	674	64.7	234.5	141.0
2015	717	65.8	247.2	144.4
2016	744	63.6	254.5	145.1
2017	754	64.2	255.7	142.3
P for trend	-	-	<0.001	0.047
Malay				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	196	25.4	395.8	375.8
2009	221	28.7	442.0	424.7
2010	195	26.3	386.9	362.2
2011	206	22.8	406.8	356.9
2012	227	24.6	445.6	395.1
2013	239	24.5	466.2	379.1
2014	255	24.5	493.6	396.8
2015	277	25.4	531.7	420.3
2016	318	27.2	604.7	466.8
2017	312	26.6	587.9	447.6
P for trend	-	-	<0.001	0.035
Indian				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	58	7.5	179.4	181.4
2009	55	7.2	160.2	156.2
2010	49	6.6	140.8	141.6
2011	64	7.1	183.5	166.0
2012	65	7.0	185.2	175.7
2013	66	6.8	187.8	165.1
2014	93	8.9	263.4	223.6
2015	80	7.3	225.4	177.6
2016	84	7.2	235.4	191.7
2017	85	7.2	236.9	183.9
P for trend	-	-	0.004	0.119

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

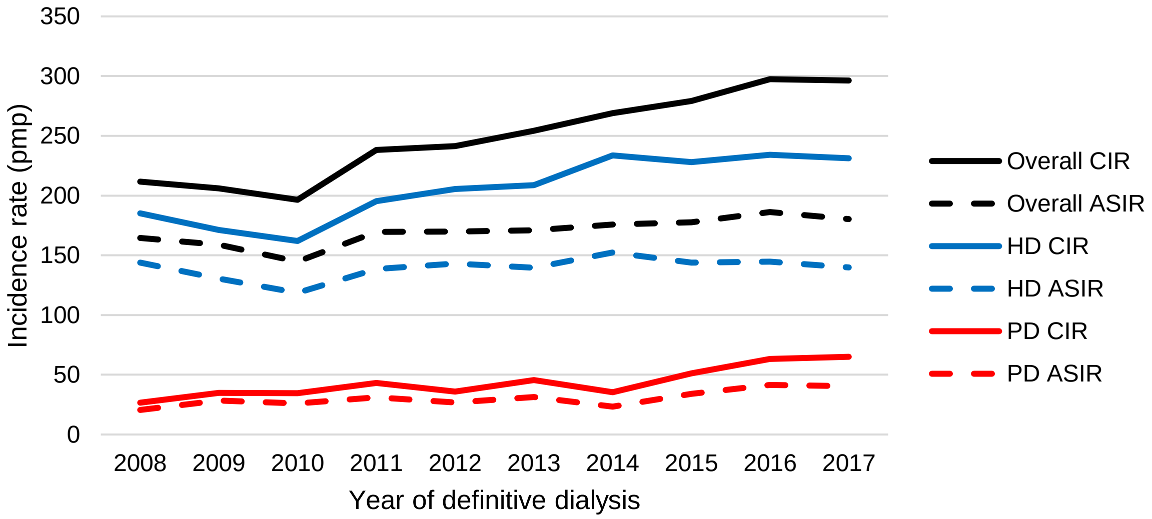


The ASIR of definitive dialysis were consistently higher among HD than PD across the years (Table 5.4.5 and Figure 5.4.6). In 2017, the ASIR was 139.7 pmp and 40.5 pmp for HD and PD respectively. While the ASIR for PD increased significantly over the years (p=0.010), the ASIR for HD remained relatively stable.

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

HD				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	674	87.4	185.0	143.9
2009	639	83.1	171.1	130.6
2010	611	82.5	162.0	118.6
2011	740	81.9	195.3	138.4
2012	785	85.1	205.6	143.0
2013	802	82.1	208.6	139.6
2014	904	86.8	233.5	152.4
2015	890	81.7	228.0	143.8
2016	921	78.7	234.1	144.8
2017	917	78.0	231.2	139.7
P for trend	-	-	0.001	0.192
PD				
Year of definitive dialysis	**Number**	**%**	**CIR**	**ASIR**
2008	97	12.6	26.6	20.5
2009	130	16.9	34.8	28.4
2010	130	17.5	34.5	26.1
2011	163	18.1	43.0	31.1
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	40.5
P for trend	-	-	0.001	0.010

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



Among new patients on definitive dialysis, diabetes was the biggest contributor to CKD5, followed by GN. In 2017, 67.1% of the new definitive dialysis patients had DN, while 14.6% had GN.

Table 5.4.6: Incidence number of definitive dialysis by etiology

Year of definitive dialysis	DN		GN		Others	
	Number	%	Number	%	Number	%
2008	488	63.3	138	17.9	145	18.8
2009	475	61.8	143	18.6	151	19.6
2010	470	63.4	137	18.5	134	18.1
2011	553	61.2	159	17.6	191	21.2
2012	608	65.9	143	15.5	171	18.5
2013	637	65.2	156	16.0	184	18.8
2014	673	64.6	165	15.9	203	19.5
2015	727	66.7	176	16.1	187	17.2
2016	779	66.6	168	14.4	223	19.1
2017	788	67.1	171	14.6	216	18.4

5.5 Prevalence of definitive dialysis

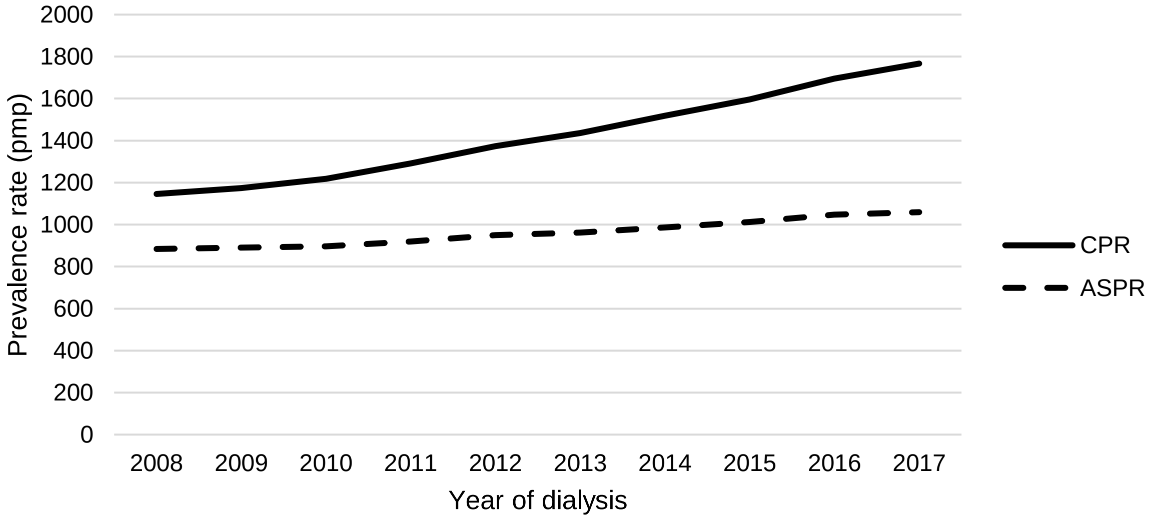
The prevalence rate in each year was computed by taking the cumulative number of surviving (existing and new) patients in a year, divided by the number of Singapore residents in the same year. Only patients surviving >90 days after initiation of dialysis were included. The count was based on the date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

Similar to the incidence trend of definitive dialysis (Table 5.4.1 and Figure 5.4.1), the number of prevalent patients on dialysis increased consistently since 2008 (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. By the end of 2017, there were a total of 7,007 surviving patients, with CPR 1,766.9 pmp and ASPR 1,059.2 pmp. The rise in ASPR implies that the rise in new patients undergoing definitive dialysis was faster than the drop in patients from those who died, even after adjusting for Singapore's ageing population.

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

Year of dialysis	Number	CPR	ASPR
2008	4174	1145.9	884.0
2009	4381	1173.4	890.9
2010	4594	1218.0	896.0
2011	4895	1291.8	919.2
2012	5245	1373.9	949.2
2013	5521	1436.1	961.8
2014	5879	1518.8	986.8
2015	6230	1596.3	1011.9
2016	6671	1695.9	1047.9
2017	7007	1766.9	1059.2
P for trend	-	<0.001	<0.001

Figure 5.5.1: Prevalence rate (pmp) of definitive dialysis



The majority of the prevalent dialysis patients were aged 50 to 79 years. In 2017, close to 80% of the prevalent dialysis patients were in this age band (Table 5.5.2).

The median age among prevalent dialysis patients increased from 59.7 years in 2008 to 63.8 years in 2017 (Figure 5.5.2a).

The rate of rise in CPR of dialysis increased with age (Figure 5.5.2b). The significant rise in overall CPR was driven by the significant rise in CPR for patients aged 30 years or older (30-39 years: $p=0.001$, 50 years or older: $p<0.001$). Conversely, there was a significant drop in CPR for those aged below 20 years ($p=0.003$).

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
2008	23	0.6	24.6	61	1.5	124.9	187	4.5	313.1	632	15.1	994.8
2009	27	0.6	29.0	58	1.3	112.4	184	4.2	299.4	629	14.4	989.9
2010	17	0.4	18.5	63	1.4	121.2	185	4.0	299.1	599	13.0	946.1
2011	17	0.3	18.9	67	1.4	129.3	185	3.8	301.4	616	12.6	976.8
2012	16	0.3	18.1	68	1.3	131.0	182	3.5	298.8	621	11.8	986.2
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	74	1.3	139.7	207	3.5	348.3	629	10.7	1007.1
2015	12	0.2	14.2	69	1.1	128.9	210	3.4	354.9	639	10.3	1030.4
2016	13	0.2	15.6	66	1.0	122.0	224	3.4	381.2	637	9.5	1036.4
2017	13	0.2	15.7	55	0.8	100.1	234	3.3	403.2	611	8.7	993.6
P for trend	-	-	0.003	-	-	0.682	-	-	0.001	-	-	0.096

Year of dialysis	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CPR	Number	%	CPR	Number	%	CPR	Number	%	CPR
2008	1229	29.4	2369.8	1172	28.1	4368.2	703	16.8	5014.3	167	4.0	2769.5
2009	1242	28.3	2311.1	1283	29.3	4487.6	779	17.8	5228.2	179	4.1	2758.1
2010	1301	28.3	2357.7	1359	29.6	4482.2	857	18.7	5434.4	213	4.6	3078.0
2011	1372	28.0	2412.9	1472	30.1	4592.8	917	18.7	5494.3	249	5.1	3401.6
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	1578	26.8	2613.0	1871	31.8	4764.5	1110	18.9	6062.0	398	6.8	4559.3
2015	1634	26.2	2678.0	2086	33.5	4932.4	1140	18.3	6201.0	440	7.1	4708.5
2016	1672	25.1	2717.9	2251	33.7	5003.6	1334	20.0	6956.9	474	7.1	4846.7
2017	1673	23.9	2722.6	2366	33.8	5070.5	1540	22.0	7283.1	515	7.3	5085.1
P for trend	-	-	<0.001	-	-	<0.001	-	-	<0.001	-	-	<0.001

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

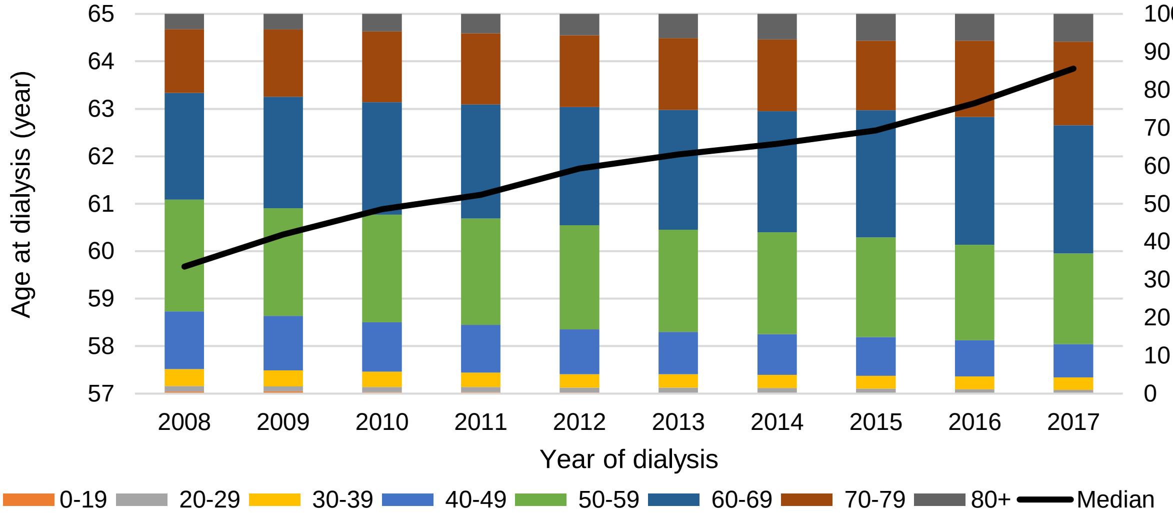
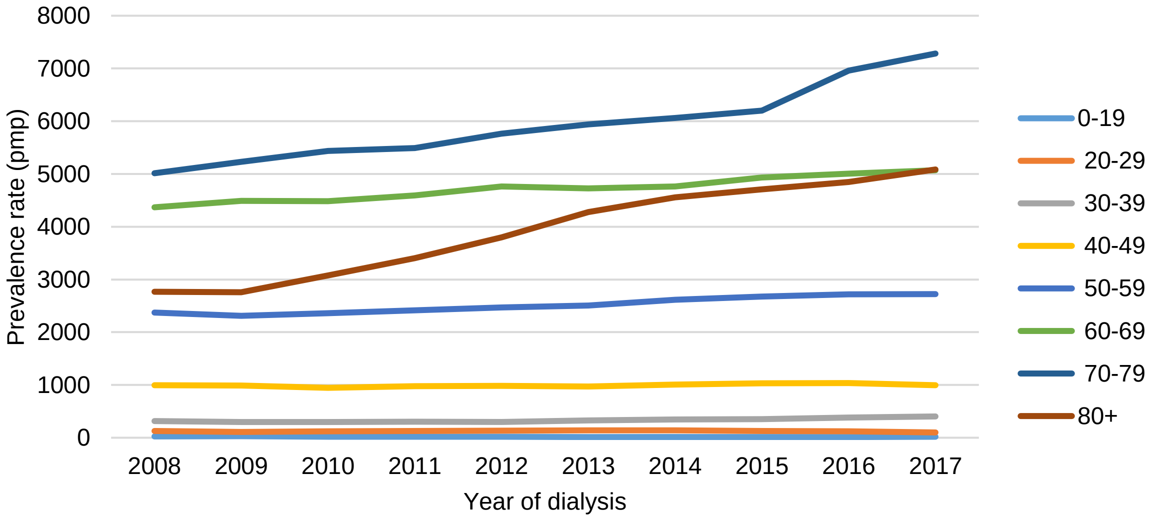
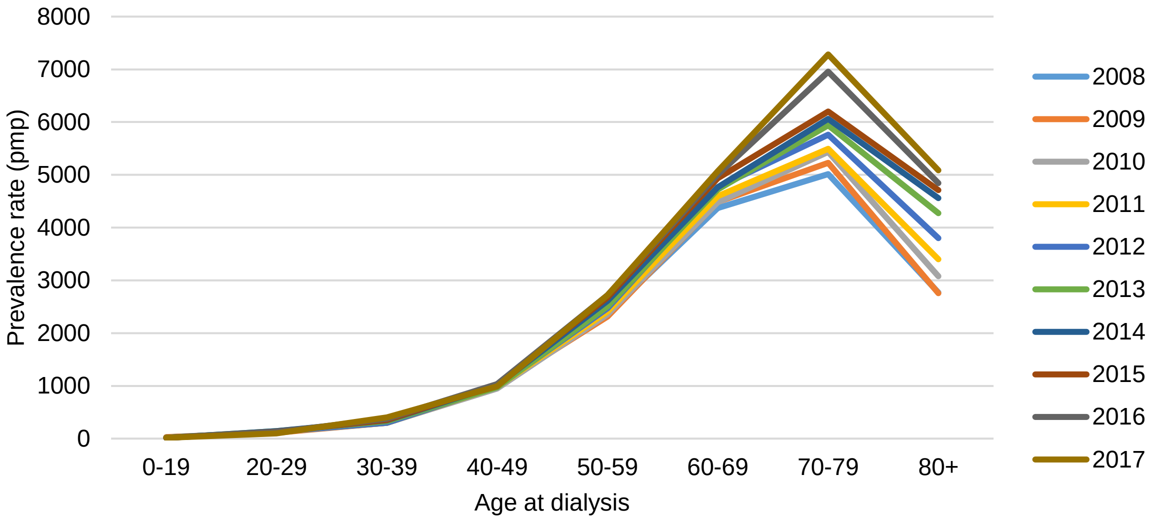


Figure 5.5.2b: Age-specific prevalence rate (pmp) of definitive dialysis across years



The CPR of dialysis increased with age, with a steep rise from age 50 to 79 years (Figure 5.5.3). However, a steep decline was observed from age 80 years onwards.

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



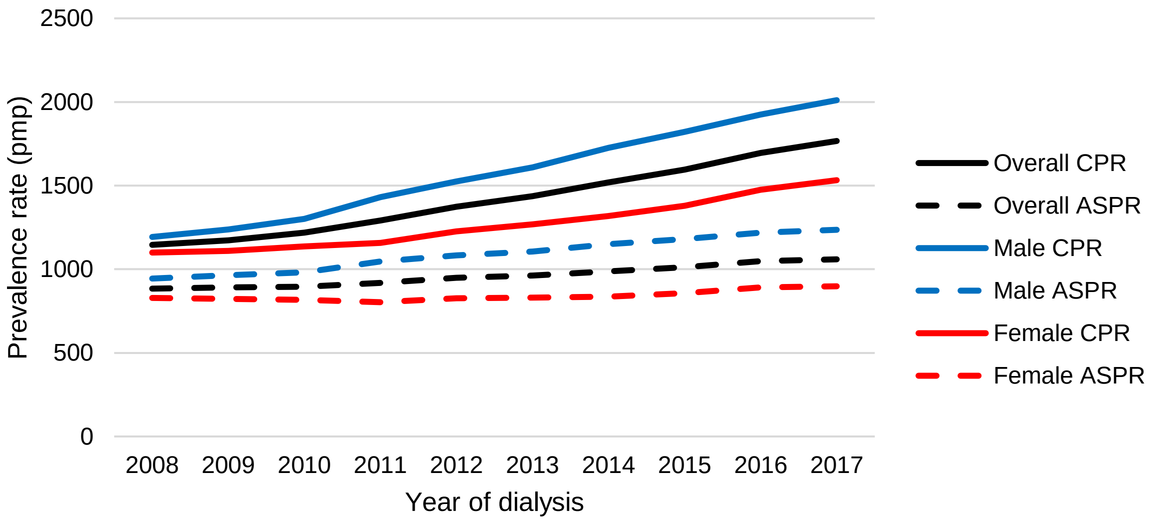
The ASPR of dialysis were consistently higher among men than women across the years (Table 5.5.3 and Figure 5.5.4). In 2017, the ASPR was 1235.8 pmp and 898.1 pmp for men and women respectively. The ASPR increased significantly over the years for both genders (p<0.001 for men and p=0.004 for women).

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

Male				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2008	2151	51.5	1193.1	944.3
2009	2284	52.1	1238.3	964.1
2010	2421	52.7	1300.8	982.1
2011	2673	54.6	1430.8	1046.0
2012	2868	54.7	1525.7	1082.5
2013	3044	55.1	1609.5	1105.5
2014	3285	55.9	1726.8	1150.5
2015	3491	56.0	1821.4	1180.7
2016	3715	55.7	1925.3	1218.1
2017	3908	55.8	2010.8	1235.8
P for trend	-	-	<0.001	<0.001

Year of dialysis	Female			
	Number	**%**	**CPR**	**ASPR**
2008	2023	48.5	1099.6	829.2
2009	2097	47.9	1110.0	821.9
2010	2173	47.3	1137.3	816.8
2011	2222	45.4	1156.7	802.9
2012	2377	45.3	1226.6	826.6
2013	2477	44.9	1268.2	830.4
2014	2594	44.1	1317.9	835.9
2015	2739	44.0	1379.1	856.2
2016	2956	44.3	1475.0	892.1
2017	3099	44.2	1532.5	898.1
P for trend	-	-	<0.001	0.004

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

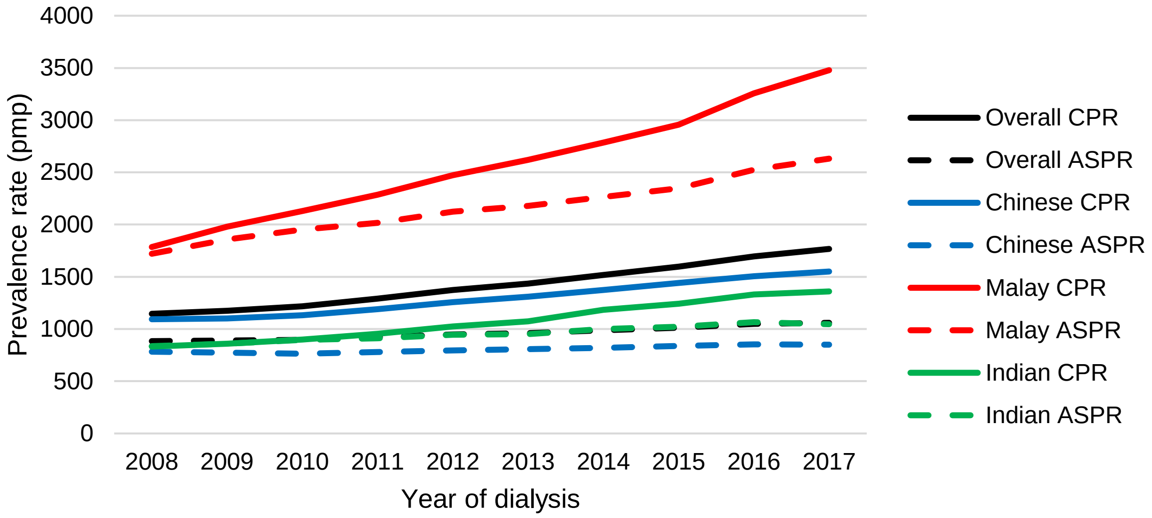


The ASPR of dialysis were consistently higher among the Malays than the Chinese and Indians across the years (Table 5.5.4 and Figure 5.5.5). In 2017, the ASPR was 849.6 pmp, 2631.3 pmp and 1047.1 pmp for the Chinese, Malays and Indians respectively. The ASPR increased significantly over the years for the three ethnic groups ($p<0.001$).

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

Chinese				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2008	2976	71.3	1093.4	782.8
2009	3053	69.7	1102.0	773.0
2010	3158	68.7	1130.3	763.5
2011	3344	68.3	1190.7	778.4
2012	3558	67.8	1256.5	796.5
2013	3739	67.7	1310.2	806.1
2014	3951	67.2	1374.6	820.2
2015	4175	67.0	1439.7	839.1
2016	4396	65.9	1503.8	852.9
2017	4571	65.2	1550.4	849.6
P for trend	-	-	<0.001	<0.001
Malay				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2008	884	21.2	1785.1	1720.7
2009	990	22.6	1980.0	1856.3
2010	1074	23.4	2131.0	1953.4
2011	1158	23.7	2286.7	2018.0
2012	1259	24.0	2471.5	2123.5
2013	1343	24.3	2619.5	2179.4
2014	1439	24.5	2785.2	2264.1
2015	1540	24.7	2956.3	2346.7
2016	1713	25.7	3257.3	2523.5
2017	1846	26.3	3478.4	2631.3
P for trend	-	-	<0.001	<0.001
Indian				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2008	269	6.4	832.0	836.1
2009	295	6.7	859.1	859.8
2010	313	6.8	899.7	896.3
2011	333	6.8	954.7	911.1
2012	360	6.9	1025.6	944.6
2013	377	6.8	1072.5	949.7
2014	418	7.1	1184.1	1000.9
2015	441	7.1	1242.4	1021.7
2016	475	7.1	1331.0	1065.6
2017	488	7.0	1360.0	1047.1
P for trend	-	-	<0.001	<0.001

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



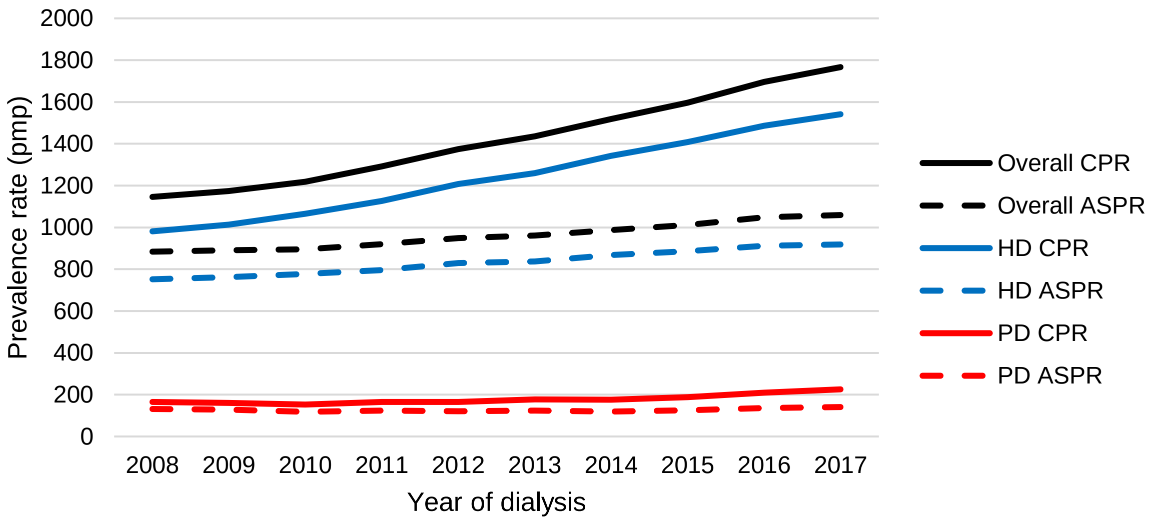
The ASPR of dialysis were consistently higher among HD than PD across the years (Table 5.5.5 and Figure 5.5.6). In 2017, the ASPR was 918.4 pmp and 140.8 pmp for HD and PD respectively. As opposed to the trend in ASIR (Table 5.4.5 and Figure 5.4.6), the ASPR for HD increased significantly over the years (p<0.001), but the ASPR for PD remained relatively stable during this period.

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

HD				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2008	3574	85.6	981.2	751.9
2009	3784	86.4	1013.5	762.8
2010	4018	87.5	1065.3	778.0
2011	4270	87.2	1126.9	795.2
2012	4613	88.0	1208.3	828.8
2013	4841	87.7	1259.2	837.8
2014	5198	88.4	1342.9	868.0
2015	5497	88.2	1408.5	886.6
2016	5848	87.7	1486.7	912.6
2017	6113	87.2	1541.4	918.4
P for trend	-	-	<0.001	<0.001

PD				
Year of dialysis	**Number**	**%**	**CPR**	**ASPR**
2008	600	14.4	164.7	132.0
2009	597	13.6	159.9	128.0
2010	576	12.5	152.7	118.0
2011	625	12.8	164.9	124.0
2012	632	12.0	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	894	12.8	225.4	140.8
P for trend	-	-	0.001	0.290

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



Compared to new definitive dialysis patients with DN (67.1% in 2017, Table 5.4.6), the proportion of prevalent dialysis patients with DN was lower at 54.2% in 2017, albeit increasing consistently since 2008 (Table 5.5.6).

Relative to new definitive dialysis patients with GN (14.6% in 2017, Table 5.4.6), the proportion of prevalent dialysis patients with GN was higher at 24.9% in 2017, albeit dropping consistently since 2008 (Table 5.5.6).

Table 5.5.6: Prevalence number of definitive dialysis by etiology

Year of dialysis	DN		GN		Others	
	Number	%	Number	%	Number	%
2008	1776	42.5	1459	35.0	939	22.5
2009	1923	43.9	1471	33.6	987	22.5
2010	2083	45.3	1492	32.5	1019	22.2
2011	2290	46.8	1523	31.1	1082	22.1
2012	2542	48.5	1555	29.6	1148	21.9
2013	2759	50.0	1567	28.4	1195	21.6
2014	2997	51.0	1610	27.4	1272	21.6
2015	3271	52.5	1678	26.9	1281	20.6
2016	3567	53.5	1721	25.8	1383	20.7
2017	3799	54.2	1742	24.9	1466	20.9

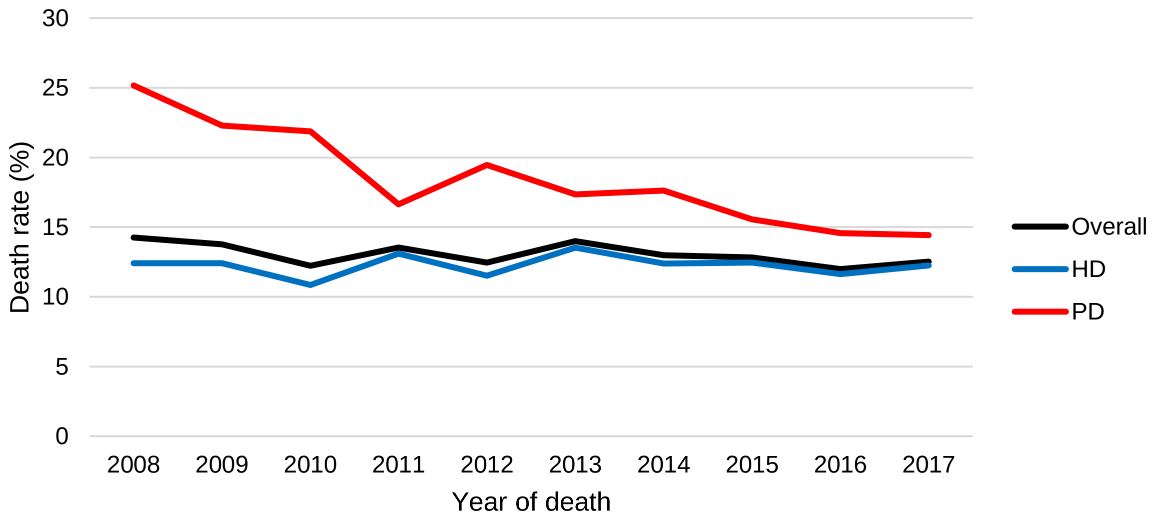
5.6 Mortality of definitive dialysis

Approximately 12% to 15% of the patients on definitive dialysis died every year in the past decade. There were consistently 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 was receiving in the last 60 days before death (Table 5.6.1 and Figure 5.6.1). However, disparity between the two modalities narrowed over the years as the death rate dropped from 25.2% in 2008 to 14.4% in 2017 for PD, while remaining relatively stable at between 11% to 14% for HD.

Table 5.6.1: All-cause mortality by modality

Year of death	Overall		HD		PD	
	Number	%	Number	%	Number	%^
2008	595	14.3	444	12.4	151	25.2
2009	603	13.8	470	12.4	133	22.3
2010	562	12.2	436	10.9	126	21.9
2011	663	13.5	559	13.1	104	16.6
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	799	12.8	685	12.5	114	15.6
2016	800	12.0	680	11.6	120	14.6
2017	878	12.5	749	12.3	129	14.4

Figure 5.6.1: All-cause mortality by modality



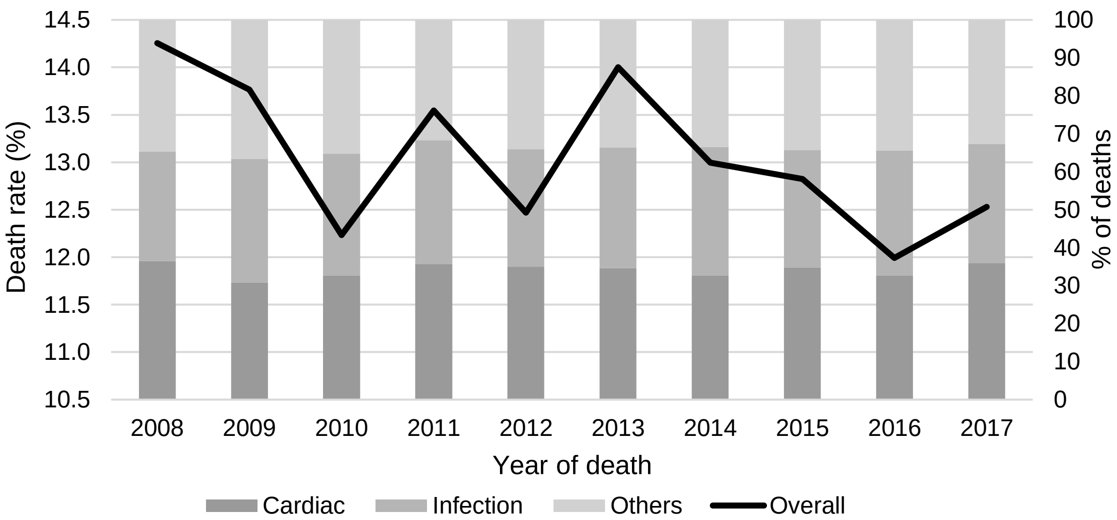
Deaths related to cardiac event and infection were the two most common causes of death and each of them accounted for about a third of all deaths across the years (Table 5.6.2 and Figure 5.6.2).

Table 5.6.2: Mortality by cause of death

Year of death	Overall		Cardiac		Infection		Others	
	Number	%*	Number	%^	Number	%^	Number	%^
2008	595	14.3	217	36.5	172	28.9	206	34.6
2009	603	13.8	186	30.8	196	32.5	221	36.7
2010	562	12.2	184	32.7	180	32.0	198	35.2
2011	663	13.5	237	35.7	216	32.6	210	31.7
2012	654	12.5	229	35.0	202	30.9	223	34.1
2013	773	14.0	268	34.7	245	31.7	260	33.6
2014	764	13.0	249	32.6	259	33.9	256	33.5
2015	799	12.8	278	34.8	247	30.9	274	34.3
2016	800	12.0	261	32.6	264	33.0	275	34.4
2017	878	12.5	315	35.9	276	31.4	287	32.7

*Mortality among prevalent dialysis patients
^Mortality among prevalent dialysis patients who died

Figure 5.6.2: Mortality by cause of death



5.7 Survival of definitive dialysis

The unadjusted survival rate and survival duration of new patients on definitive dialysis were estimated using the Kaplan-Meier method in Table 5.7.1 to 5.7.10. Event was defined as all-cause death. Patients were censored if they received kidney transplant or neither received kidney transplant nor died by 28 February 2018, the date at which the death status of all patients registered in the SRR were updated until. Median survival duration is indicated as "not reached (NR)" if more than half of the patients were still alive as of 28 February 2018. Cox regression model was used to adjust for the effects of potential confounders on the survival of patients in Table 5.7.11.

All analyses in this section were stratified by or adjusted for modality as survival differed between HD and PD patients. The modality was based on the last modality that the dialysis patient was receiving in the last 60 days before death.

Compared to PD patients, HD patients had significantly better survival as indicated by their higher survival rates and longer median survival duration ($p<0.001$) (Table 5.7.1).

Table 5.7.1: Survival of definitive dialysis by modality

	HD	PD	Overall
1-year survival (%)	90.5	88.6	90.0
5-year survival (%)	61.1	40.5	56.5
10-year survival (%)	35.7	21.1	32.4
Median survival (years)	6.8	3.9	6.0

Although survival among HD patients was fairly similar over the years, survival among PD patients significantly improved over time ($p<0.001$) (Table 5.7.2).

Table 5.7.2: Survival of definitive dialysis by period of dialysis and modality

	1999-2002	2003-2007	2008-2012	2013-2017
HD				
1-year survival (%)	91.5	89.2	90.0	91.6
5-year survival (%)	62.4	59.0	60.5	-
10-year survival (%)	40.1	33.7	-	-
Median survival (years)	7.6	6.5	6.6	NR
PD				
1-year survival (%)	84.3	87.5	90.2	92.4
5-year survival (%)	32.2	37.9	45.7	-
10-year survival (%)	16.3	20.2	-	-
Median survival (years)	3.2	3.7	4.5	NR
Overall				
1-year survival (%)	89.1	88.7	89.9	91.7
5-year survival (%)	52.0	53.7	58.1	-
10-year survival (%)	31.9	30.3	-	-
Median survival (years)	5.3	5.6	6.2	NR

Younger patients aged below 60 years had significantly better survival than older patients aged 60 years or older (HD and PD: p<0.001) (Table 5.7.3).

Table 5.7.3: Survival of definitive dialysis by age group and modality

	Age <60 years			Age ≥60 years		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	93.3	92.5	93.2	87.8	85.3	87.2
5-year survival (%)	72.4	57.9	69.5	49.5	26.2	43.9
10-year survival (%)	50.8	37.9	48.2	18.7	6.6	15.7
Median survival (years)	10.4	6.3	9.5	4.9	3.0	4.2

Survival was fairly similar between the two genders (Table 5.7.4).

Table 5.7.4: Survival of definitive dialysis by gender and modality

	Male			Female		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	90.4	88.7	90.0	90.7	88.5	90.1
5-year survival (%)	60.6	41.5	56.9	61.7	39.6	56.1
10-year survival (%)	36.0	20.7	32.9	35.5	21.3	31.9
Median survival (years)	6.8	4.1	6.1	6.8	3.8	5.9

Survival was fairly similar across the three ethnic groups (Table 5.7.5).

Table 5.7.5: Survival of definitive dialysis by ethnicity and modality

	Chinese			Malay			Indian		
	HD	PD	Overall	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	90.8	88.8	90.3	90.1	87.7	89.7	89.8	89.7	89.8
5-year survival (%)	60.8	41.0	56.1	62.6	38.8	57.9	59.4	39.5	55.7
10-year survival (%)	35.6	20.6	32.1	36.8	22.8	34.0	33.1	20.1	30.6
Median survival (years)	6.7	4.0	5.9	7.1	3.7	6.3	6.1	3.7	5.8

Patients without DN had significantly better survival than those with DN (HD and PD: p<0.001) (Table 5.7.6).

Table 5.7.6: Survival of definitive dialysis by etiology and modality

	Non-DN			DN		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	92.5	92.3	92.4	89.2	86.3	88.6
5-year survival (%)	73.0	62.3	70.8	52.7	27.1	46.7
10-year survival (%)	54.3	40.8	51.5	21.0	8.1	18.0
Median survival (years)	11.3	7.6	10.5	5.3	3.1	4.6

Patients without IHD had significantly better survival than those with IHD (HD and PD: p<0.001) (Table 5.7.7).

Table 5.7.7: Survival of definitive dialysis by presence of IHD and modality

	No IHD			IHD		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	93.0	91.8	92.7	87.8	85.4	87.3
5-year survival (%)	70.9	54.7	67.6	49.6	26.8	44.0
10-year survival (%)	47.6	34.3	44.9	20.2	8.7	17.3
Median survival (years)	9.3	5.6	8.6	5.0	3.1	4.2

Patients without cerebrovascular disease (CVD) had significantly better survival than those with CVD (HD and PD: p<0.001) (Table 5.7.8).

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

	No CVD			CVD		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	91.7	90.4	91.5	86.5	84.2	85.9
5-year survival (%)	65.1	46.5	61.2	47.3	25.4	41.4
10-year survival (%)	39.9	25.4	36.9	18.9	9.6	16.3
Median survival (years)	7.6	4.5	6.9	4.7	2.9	4.0

Patients without peripheral vascular disease (PVD) had significantly better survival than those with PVD (HD and PD: p<0.001) (Table 5.7.9).

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

	No PVD			PVD		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	91.8	90.0	91.4	84.3	81.1	83.6
5-year survival (%)	64.6	44.7	60.2	43.4	19.6	38.5
10-year survival (%)	39.5	24.2	36.1	14.2	2.5	11.8
Median survival (years)	7.5	4.4	6.7	4.1	2.5	3.6

Patients without cancer had significantly better survival than those with cancer (HD: p<0.001, PD: p=0.007) (Table 5.7.10).

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

	No cancer			Cancer		
	HD	PD	Overall	HD	PD	Overall
1-year survival (%)	91.8	90.8	91.6	82.7	87.0	83.2
5-year survival (%)	63.9	44.9	59.8	45.2	32.9	43.7
10-year survival (%)	37.7	23.5	34.6	22.2	14.7	21.2
Median survival (years)	7.3	4.4	6.6	4.4	3.3	4.1

PD, old age, DN, IHD, CVD, PVD and cancer were significant predictors of death (Table 5.7.11).

Table 5.7.11: Adjusted risk of death by factors associated with survival of definitive dialysis

	Hazard ratio	95% confidence interval	P-value
Modality			
HD	Reference		<0.001
PD	1.54	1.46-1.62	
Age group			
<60 years	Reference		<0.001
≥60 years	2.07	1.97-2.18	
Gender			
Male	Reference		0.924
Female	1.00	0.96-1.05	
Ethnicity			
Chinese	Reference		
Malay	1.00	0.95-1.06	0.958
Indian	0.98	0.90-1.07	0.691
Etiology			
Non-DN	Reference		<0.001
DN	1.86	1.77-1.97	
IHD			
No	Reference		<0.001
Yes	1.50	1.42-1.57	
CVD			
No	Reference		<0.001
Yes	1.35	1.28-1.42	
PVD			
No	Reference		<0.001
Yes	1.52	1.43-1.61	
Cancer			
No	Reference		<0.001
Yes	1.51	1.39-1.64	

5.8 Management of definitive dialysis

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 under each aspect are as follow:

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) >2.10 mmol/L and <2.37 mmol/L
		Serum phosphate (PO_4) >1.13 mmol/L and <1.78 mmol/L
		Serum intact parathyroid hormone (iPTH) >16.3 mmol/L and <33.0 mmol/L

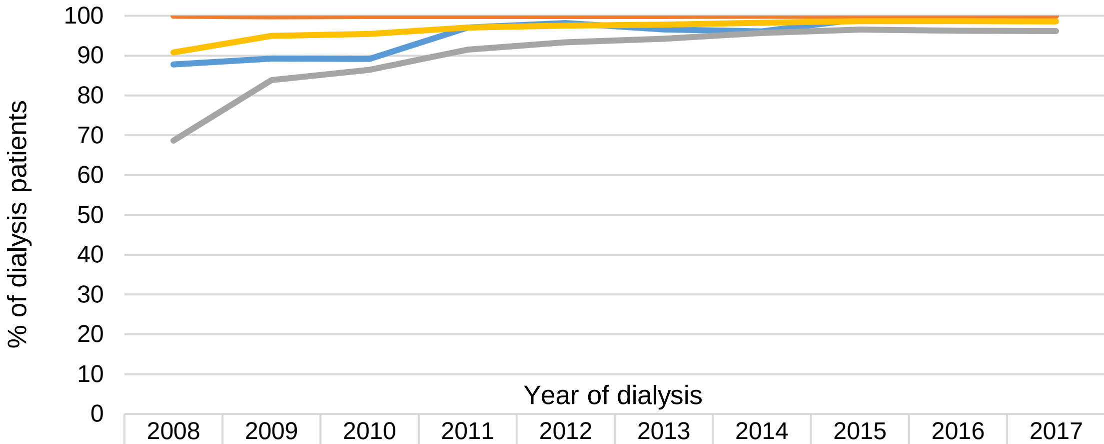
All analyses in this section were stratified by service provider (public sector / VWO / private sector) and modality (HD / PD) so as to sieve out groups of patients in need of better management. The most recent reading of each bio-clinical indicators for each patient in each year were taken and patients without measurement of bio-clinical indicators were excluded, where relevant.

The majority of the prevalent HD patients were dialysed in centres run by the VWO, followed by the private sector, then the public sector. In 2017, the proportions of HD patients under the care of the VWO, private sector and public sector were 62.3%, 36.1% and 1.6% 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 relatively less stable trends.

On the contrary, almost all of the prevalent PD patients were cared for by the public sector. In 2017, 99.7% of the PD patients fell under the care of the public sector, with no patient under the care of the VWO (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 VWO in 2017, their trends were either unstable or not applicable. Hence, statistics related to PD patients from the private sector in the past decade and the VWO in 2017 were excluded from this section.

The proportion of prevalent HD patients with thrice weekly dialysis was consistently higher for the public sector and VWO than the private sector across the years (Figure 5.8.1a). However, the disparity narrowed over the years with 96.1% of the private sector patients undergoing thrice weekly dialysis in 2017, compared to 100% of the public and VWO patients.

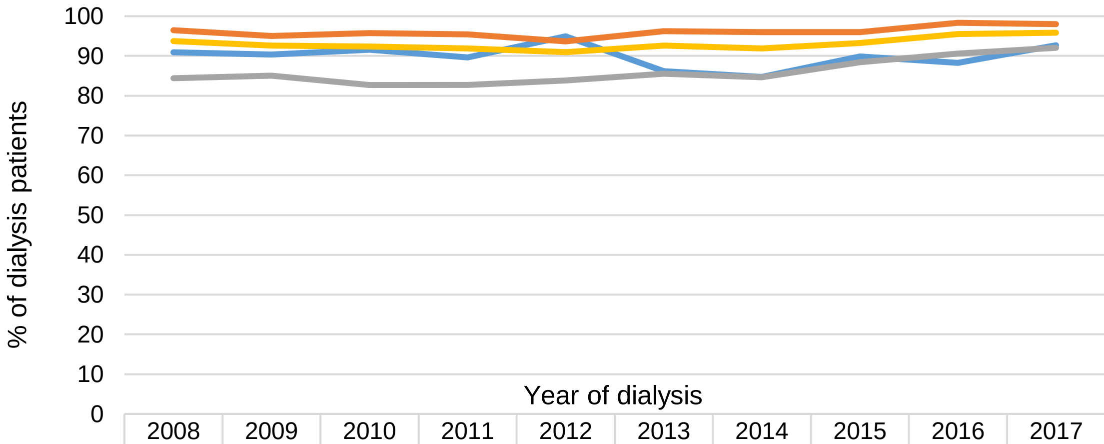
Figure 5.8.1a: Proportion of HD patients with thrice weekly dialysis



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	87.8	89.2	89.1	97.1	98.1	96.6	96.0	99.1	99.0	100.0
VWO	100.0	99.8	99.9	99.9	100.0	99.9	100.0	99.9	100.0	100.0
Private	68.6	83.8	86.4	91.5	93.3	94.3	95.7	96.5	96.2	96.1
Overall	90.8	94.9	95.4	97.0	97.5	97.7	98.3	98.6	98.6	98.6

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 VWO than the public and private sectors (Figure 5.8.1b). However, the private sector was catching up - rising from 84.4% of its patients meeting the criteria in 2008 to 92.1% in 2017. The corresponding proportions for the public sector and VWO were 92.7% and 98.0% respectively in 2017.

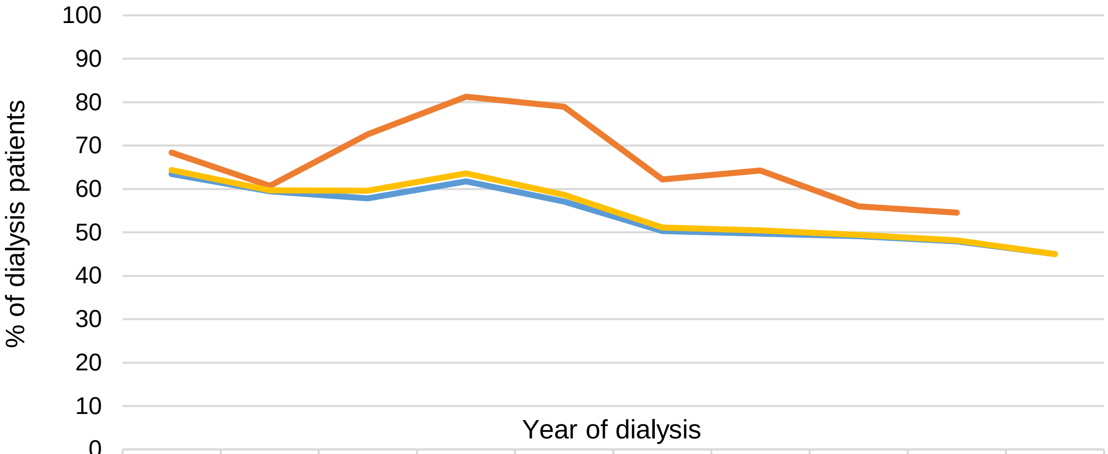
Figure 5.8.1b: Proportion of HD patients with adequate management of urea (URR >=65% or Kt/V >=1.2%)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	90.9	90.4	91.6	89.7	94.9	86.2	84.7	89.9	88.2	92.7
VWO	96.5	95.0	95.8	95.4	93.7	96.2	96.0	96.0	98.3	98.0
Private	84.4	85.1	82.7	82.7	83.9	85.5	84.7	88.4	90.6	92.1
Overall	93.7	92.6	92.4	91.9	91.0	92.6	91.9	93.3	95.5	95.8

The proportion of prevalent PD patients who met the adequate management of urea criteria of Kt/V >=2.0% was consistently higher for the VWO than the public sector across the years (Figure 5.8.2). In 2016, 47.9% of the public sector patients and 54.5% of the VWO patients met the criteria.

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

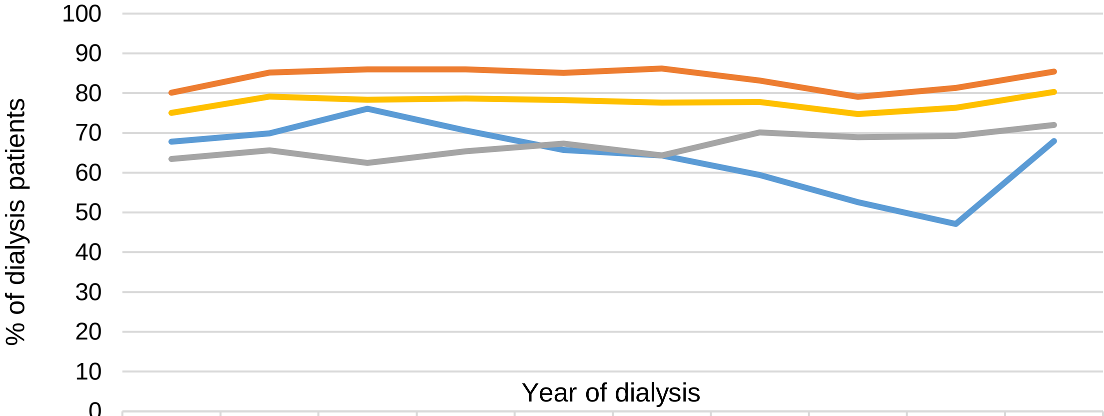


	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	63.4	59.4	57.8	61.7	57.1	50.3	49.7	49.1	47.9	45.0
VWO	68.4	60.7	72.6	81.3	78.9	62.2	64.3	56.0	54.5	
Overall	64.4	59.6	59.6	63.6	58.6	51.1	50.5	49.4	48.2	45.0

The proportion of prevalent HD patients who fulfilled the adequate management of anaemia criteria of hb >=10 g/dL was consistently higher for the VWO than the public and private sectors across the years (Figure 5.8.3a). However, the private sector was catching up - rising from 63.5% of its patients meeting the criteria in 2008 to 72.0% in 2017. The corresponding proportions for the public sector and VWO were 68.0% and 85.4% respectively in 2017.

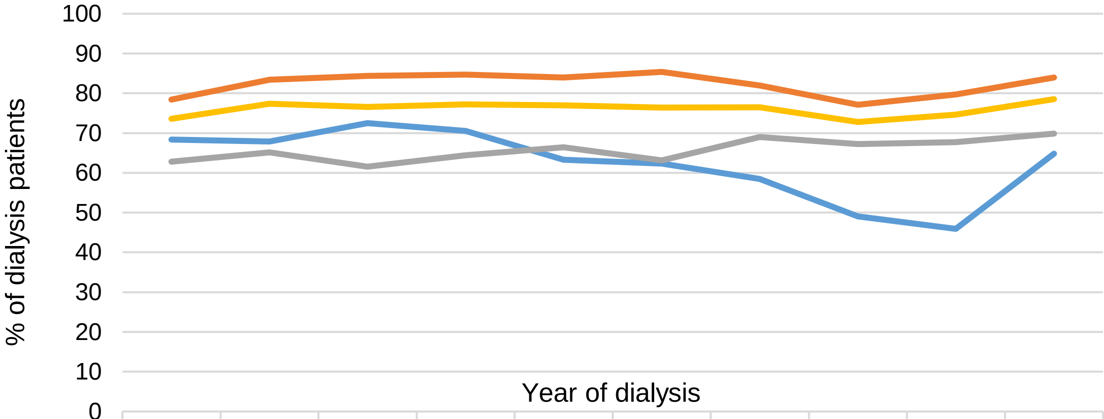
Similar trends were observed after stratification by ESA, a drug that stimulates the production of erythropoietin, a hormone produced primarily by the kidneys and plays a key role in the production of red blood cells (Figures 5.8.3b and 5.8.3c). In addition, the proportion of prevalent HD patients who 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)



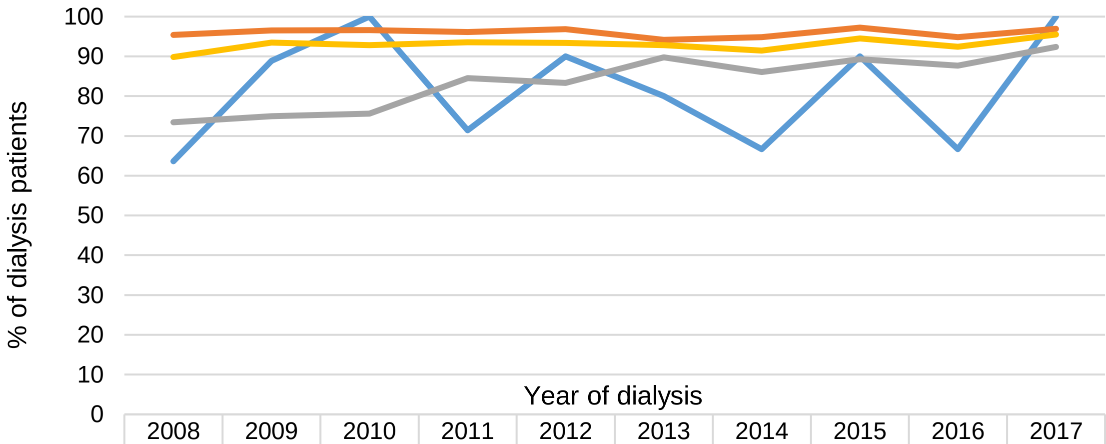
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	67.8	69.9	76.1	70.6	65.7	64.4	59.4	52.6	47.1	68.0
VWO	80.1	85.2	86.0	86.0	85.1	86.2	83.1	79.1	81.3	85.4
Private	63.5	65.6	62.5	65.4	67.3	64.3	70.1	68.9	69.2	72.0
Overall	75.1	79.1	78.3	78.7	78.2	77.6	77.7	74.7	76.4	80.3

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



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	68.4	67.9	72.5	70.5	63.3	62.3	58.4	49.0	45.9	64.8
VWO	78.4	83.4	84.4	84.7	83.9	85.4	81.9	77.1	79.7	84.0
Private	62.8	65.1	61.6	64.4	66.4	63.2	69.0	67.2	67.7	69.9
Overall	73.6	77.3	76.5	77.2	77.0	76.4	76.5	72.8	74.7	78.5

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

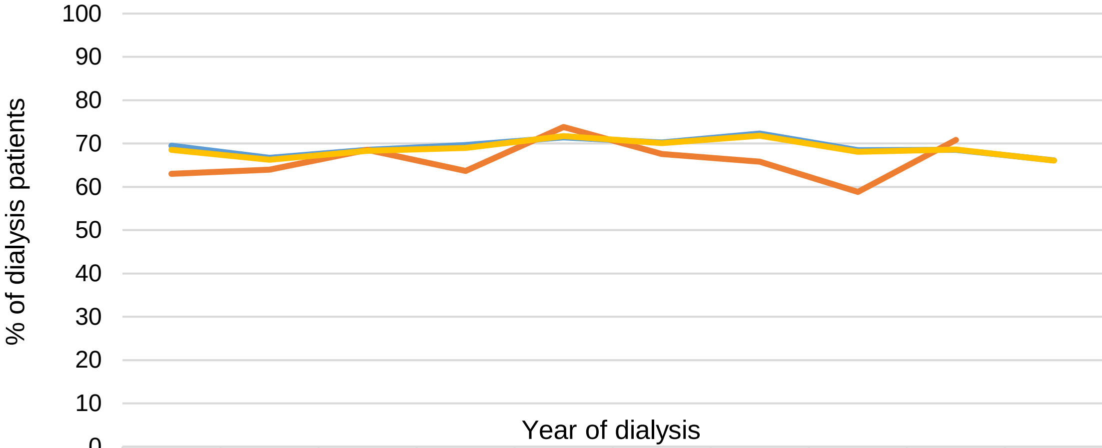


	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	63.6	88.9	100.0	71.4	90.0	80.0	66.7	90.0	66.7	100.0
VWO	95.4	96.6	96.6	96.1	96.9	94.2	94.8	97.2	94.8	96.9
Private	73.4	75.0	75.6	84.5	83.3	89.7	86.0	89.3	87.7	92.4
Overall	89.8	93.5	92.8	93.5	93.4	92.8	91.4	94.5	92.4	95.5

The proportion of prevalent PD patients who fulfilled the adequate management of anaemia criteria of hb >=10 g/dL was fairly similar for the public sector and VWO (Figure 5.8.4a). In 2016, 68.5% of the public sector patients and 70.8% of the VWO patients fulfilled the criteria.

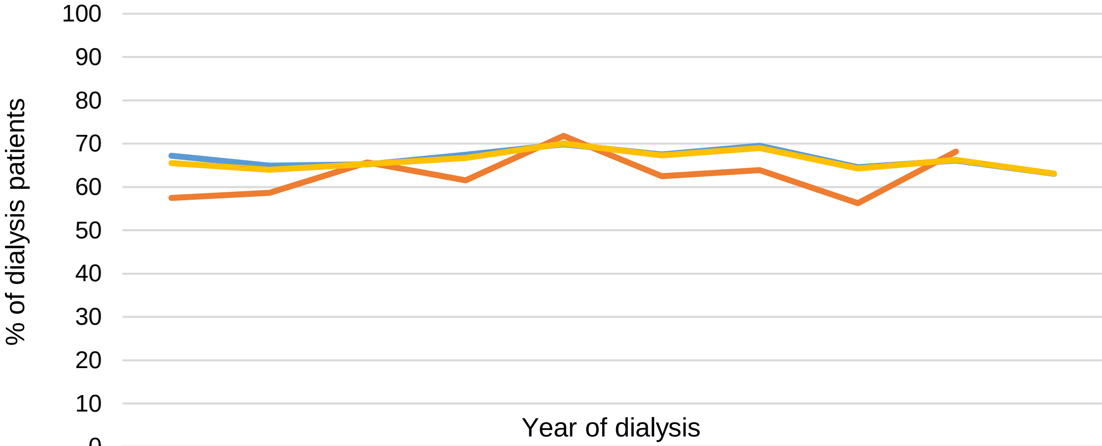
Similar trends were observed among PD patients who were taking ESA (Figure 5.8.4b). However, among PD patients who were not on ESA, all the patients from VWO fulfilled the criteria and their proportion was consistently higher than the public sector across the years (Figure 5.8.4c). Similar to HD patients, 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)



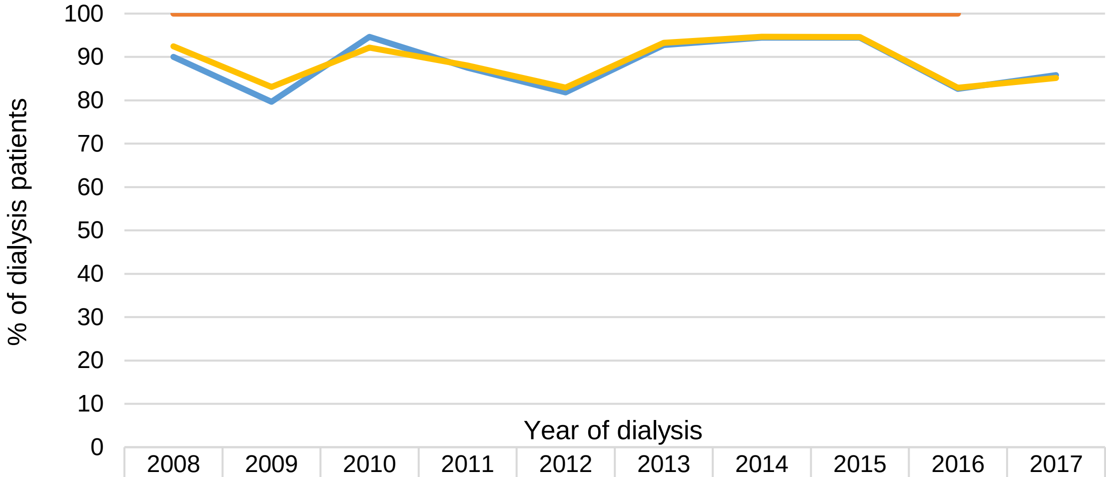
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	69.5	66.7	68.5	69.7	71.4	70.2	72.3	68.4	68.5	66.1
VWO	63.0	64.0	68.6	63.6	73.8	67.6	65.8	58.8	70.8	
Overall	68.5	66.3	68.3	69.0	71.7	70.1	71.8	68.1	68.6	66.1

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



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	67.2	64.9	65.2	67.4	69.8	67.5	69.5	64.6	66.1	63.0
VWO	57.5	58.7	65.6	61.5	71.8	62.5	63.9	56.3	68.2	
Overall	65.5	64.0	65.3	66.7	70.0	67.3	69.0	64.3	66.2	63.1

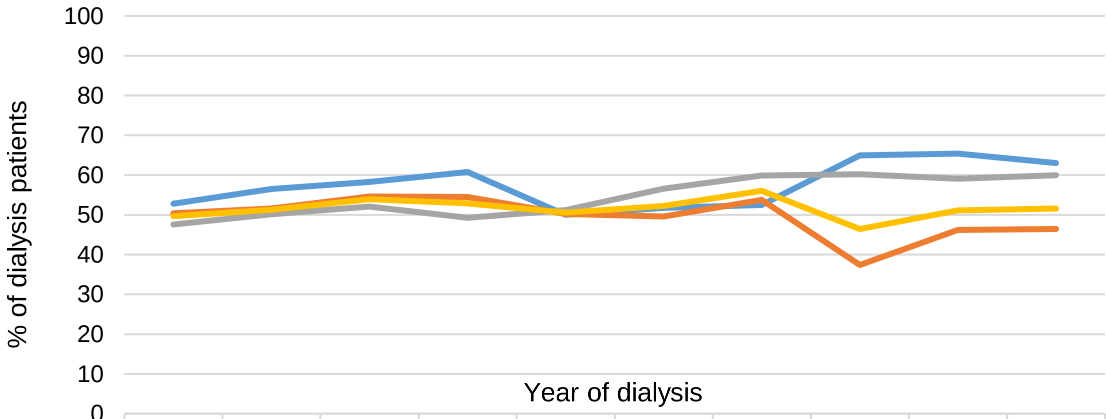
Figure 5.8.4c: Proportion of PD patients not on ESA with adequate management of anaemia (hb >=10 g/dL)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	90.0	79.7	94.6	87.5	81.8	92.8	94.4	94.4	82.6	85.8
VWO	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Overall	92.4	83.1	92.2	88.1	82.9	93.2	94.7	94.6	82.9	85.1

The proportion of prevalent HD patients who passed the adequate management of mineral and bone disease criteria of corrected serum Ca >2.10 mmol and <2.37 mmol was fairly similar across the three broad service providers from 2008 to 2014 (Figure 5.8.5). However, from 2015 onwards, the proportion of patients passing the criteria was distinctly highest for the public sector (63.0% in 2017), followed by the private sector (59.9%), then the VWO (46.4%).

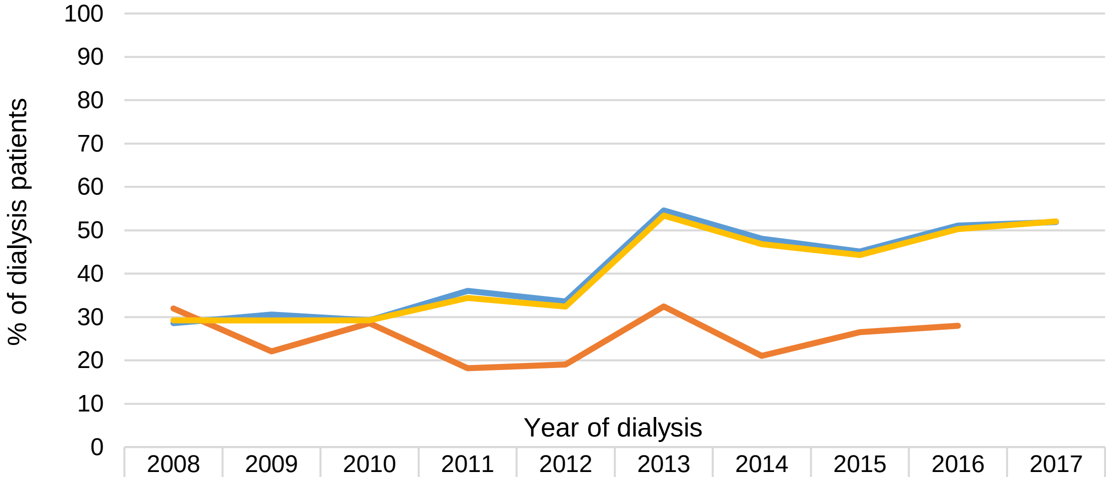
Figure 5.8.5: Proportion of HD patients with adequate management of mineral and bone disease (corrected serum Ca >2.10 mmol/L and <2.37 mmol/L)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	52.8	56.5	58.2	60.8	50.0	51.7	52.5	64.9	65.4	63.0
VWO	50.4	51.6	54.6	54.5	50.2	49.6	53.8	37.4	46.2	46.4
Private	47.6	50.1	52.1	49.2	51.2	56.6	59.9	60.2	59.0	59.9
Overall	49.6	51.3	53.9	52.9	50.6	52.2	56.0	46.4	51.1	51.6

The proportion of prevalent PD patients who passed the adequate management of mineral and bone disease criteria of corrected serum Ca >2.10 mmol and <2.37 mmol was consistently higher for the public sector than the VWO since 2009 (Figure 5.8.6). In 2016, 51.1% of the public sector patients and 28.0% of the VWO patients passed the criteria.

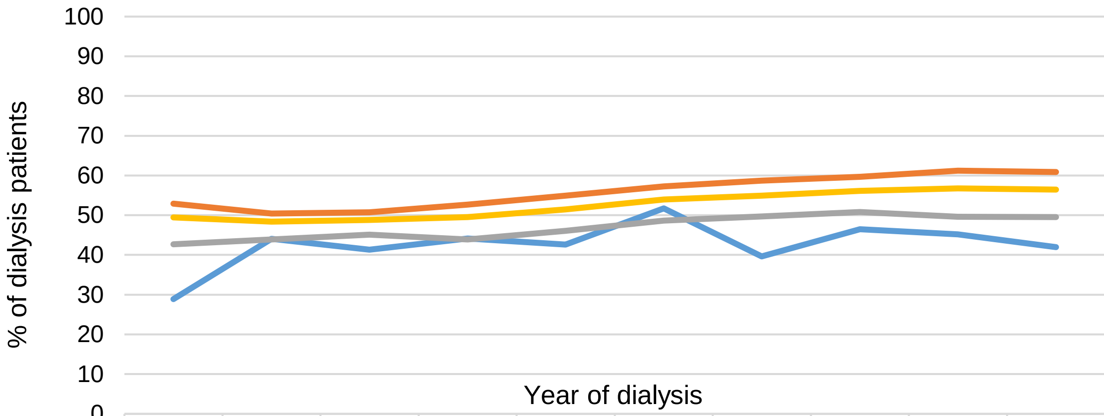
Figure 5.8.6: Proportion of PD patients with adequate management of mineral and bone disease (corrected serum Ca >2.10 mmol/L and <2.37 mmol/L)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	28.6	30.5	29.3	36.0	33.6	54.6	48.0	45.1	51.1	51.9
VWO	32.0	22.1	28.6	18.2	19.0	32.4	21.1	26.5	28.0	
Overall	29.2	29.2	29.2	34.4	32.4	53.4	46.8	44.3	50.3	52.0

The proportion of prevalent HD patients who passed the adequate management of mineral and bone disease criteria of serum PO_4 >1.13 mmol and <1.78 mmol was consistently higher for the VWO than the public and private sectors across the years (Figure 5.8.7). In 2017, the proportion of patients passing the criteria was 42.0%, 60.9% and 49.5% for the public sector, VWO and private sector respectively.

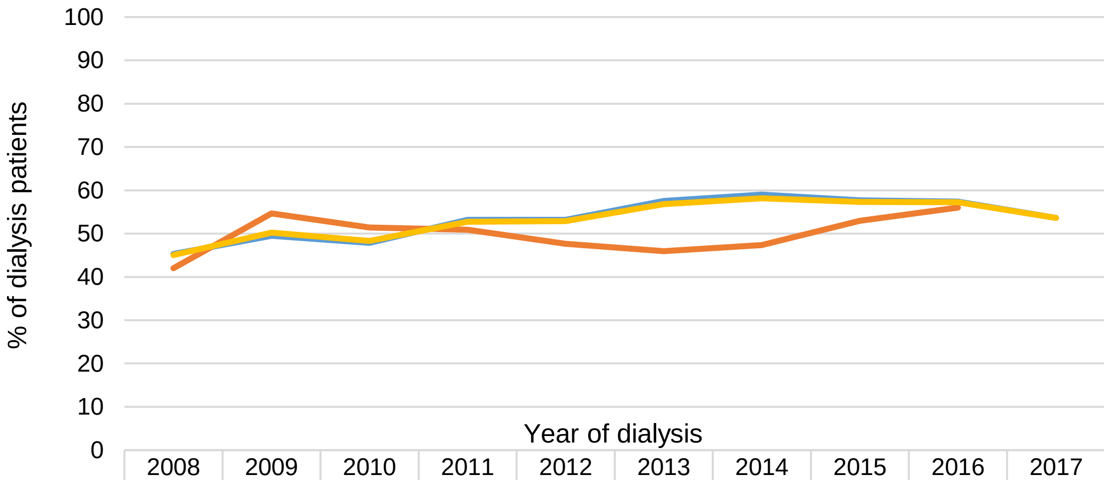
Figure 5.8.7: Proportion of HD patients with adequate management of mineral and bone disease (serum PO_4 >1.13 mmol/L and <1.78 mmol/L)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	28.9	44.1	41.3	44.1	42.6	51.7	39.6	46.5	45.2	42.0
VWO	52.9	50.4	50.8	52.7	54.9	57.3	58.7	59.7	61.2	60.9
Private	42.7	43.9	45.1	43.9	46.0	48.6	49.7	50.8	49.6	49.5
Overall	49.4	48.4	48.8	49.5	51.4	53.9	54.9	56.1	56.8	56.5

The proportion of prevalent PD patients who passed the adequate management of mineral and bone disease criteria of serum PO_4 >1.13 mmol and <1.78 mmol was consistently higher for the public sector than the VWO from 2011 onwards (Figure 5.8.8). However, the VWO was catching up - rising from 50.9% of its patients passing the criteria in 2011 to 56.0% in 2016. The corresponding proportion for the public sector was 57.4% in 2016.

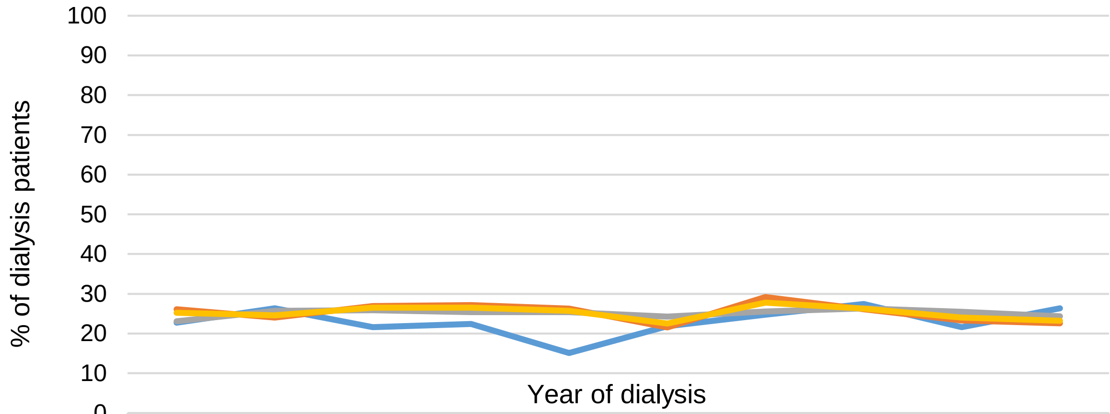
Figure 5.8.8: Proportion of PD patients with adequate management of mineral and bone disease (serum PO_4 >1.13 mmol/L and <1.78 mmol/L)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	45.3	49.5	47.9	53.2	53.2	57.6	59.0	57.7	57.4	53.6
VWO	42.0	54.7	51.4	50.9	47.6	45.9	47.4	52.9	56.0	
Overall	45.0	50.3	48.3	52.7	52.9	56.8	58.1	57.3	57.2	53.6

The proportion of prevalent HD patients who passed the adequate management of mineral and bone disease criteria of serum iPTH >16.3 mmol and <33.0 mmol was fairly similar across the three broad service providers with the exception of the period 2010 to 2012, where the proportion of public sector patients passing the criteria was clearly lower than the VWO and private sector (Figure 5.8.9). In 2017, the proportion of patients passing the criteria was 26.3%, 22.6% and 24.3% for the public sector, VWO and private sector respectively.

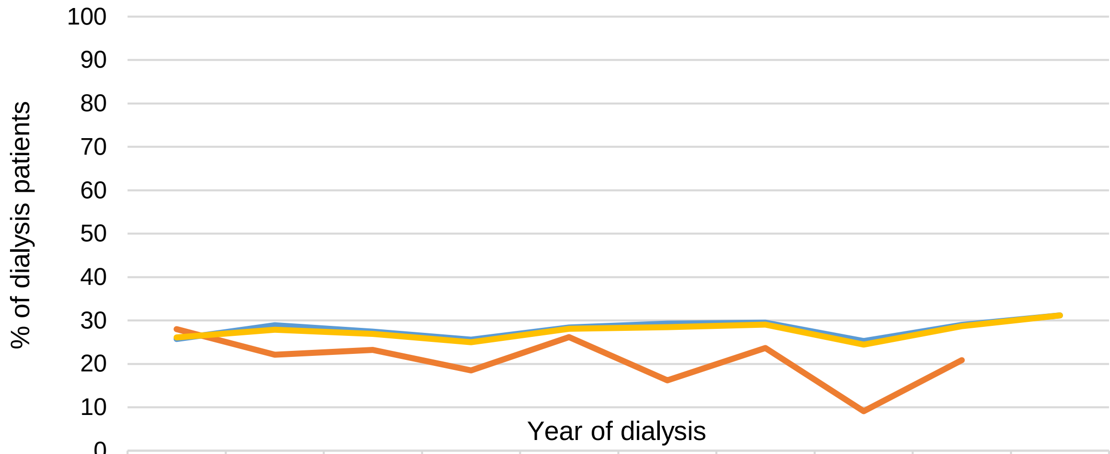
Figure 5.8.9: Proportion of HD patients with adequate management of mineral and bone disease (serum iPTH >16.3 mmol/L and <33.0 mmol/L)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	22.7	26.4	21.6	22.4	15.1	21.8	24.7	27.4	21.6	26.3
VWO	26.1	24.0	26.9	27.2	26.2	21.5	29.2	26.1	23.3	22.6
Private	23.1	25.7	25.8	25.4	25.4	24.3	25.6	26.3	25.5	24.3
Overall	25.2	24.6	26.5	26.5	25.7	22.5	27.8	26.2	24.0	23.3

The proportion of prevalent PD patients who passed the adequate management of mineral and bone disease criteria of serum iPTH >16.3 mmol and <33.0 mmol was consistently higher for the public sector than VWO since 2009 (Figure 5.8.10). In 2016, 29.0% of the public sector patients and 20.8% of the VWO patients passed the criteria.

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



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Public	25.7	28.9	27.5	25.6	28.4	29.2	29.5	25.3	29.0	31.2
VWO	28.0	22.1	23.2	18.5	26.2	16.2	23.7	9.1	20.8	
Overall	26.1	27.8	26.9	25.0	28.1	28.5	29.1	24.4	28.7	31.2

5.9 Incidence of kidney transplant

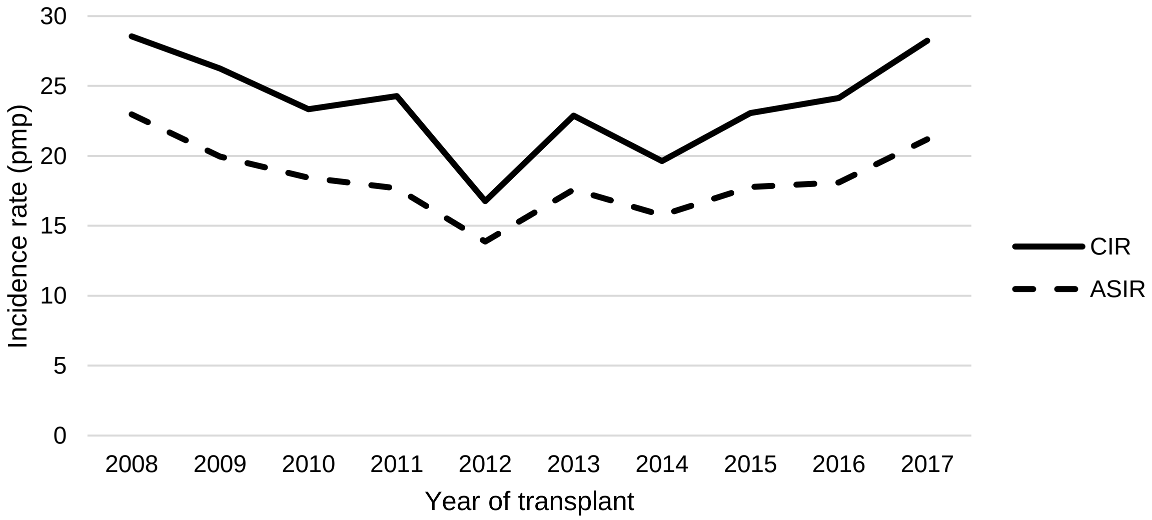
The incidence rate in each year was computed by taking the number of new kidney transplants in a year, divided by the number of Singapore residents in the same year. The count was based on the date of nephrectomy. The data had been cleaned with reference to data from the National Organ Transplant Unit. Patients (receiving the kidney) were categorized into 10-year age groups and age standardization was done using the direct method with the Segi World population as the standardization weights.

The number of new kidney transplants decreased from 104 in 2008 to 64 in 2012, but increased thereafter to 112 in 2017 (Table 5.9.1 and Figure 5.9.1). Correspondingly, the CIR and ASIR dropped to the lowest point of 16.8 pmp and 13.9 pmp respectively in 2012, but increased to almost the same rates as those in 2008 by 2017.

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

Year of transplant	Number	CIR	ASIR
2008	104	28.6	23.0
2009	98	26.2	19.9
2010	88	23.3	18.4
2011	92	24.3	17.7
2012	64	16.8	13.9
2013	88	22.9	17.6
2014	76	19.6	15.8
2015	90	23.1	17.8
2016	95	24.2	18.1
2017	112	28.2	21.2
P for trend	-	0.739	0.550

Figure 5.9.1: Incidence rate (pmp) of kidney transplant



The majority of the new kidney transplant patients were aged 40 to 59 years. In 2017, close to 60% of new kidney transplant patients were in this age band (Table 5.9.2).

The median age at kidney transplant fluctuated between 43 years and 52 years in 2008 to 2017 (Figure 5.9.2a).

Due to the small number of kidney transplants done each year, the CIR of kidney transplant for every age group fluctuated randomly over the years (Figure 5.9.2b).

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
2008	6	5.8	6.4	10	9.6	20.5	20	19.2	33.5	34	32.7	53.5
2009	2	2.0	2.1	11	11.2	21.3	9	9.2	14.6	34	34.7	53.5
2010	7	8.0	7.6	3	3.4	5.8	10	11.4	16.2	30	34.1	47.4
2011	2	2.2	2.2	5	5.4	9.7	15	16.3	24.4	23	25.0	36.5
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	7.9	7.0	7	9.2	13.2	7	9.2	11.8	20	26.3	32.0
2015	2	2.2	2.4	12	13.3	22.4	15	16.7	25.4	24	26.7	38.7
2016	5	5.3	6.0	5	5.3	9.2	12	12.6	20.4	20	21.1	32.5
2017	3	2.7	3.6	8	7.1	14.6	17	15.2	29.3	32	28.6	52.0
P for trend	-	-	0.992	-	-	0.856	-	-	0.887	-	-	0.445
Year of transplant	Age 50-59			Age 60-69			Age 70-79			Age 80+		
	Number	%	CIR	Number	%	CIR	Number	%	CIR	Number	%	CIR
2008	25	24.0	48.2	9	8.7	33.5	0	0.0	0.0	0	0.0	0.0
2009	36	36.7	67.0	6	6.1	21.0	0	0.0	0.0	0	0.0	0.0
2010	28	31.8	50.7	9	10.2	29.7	1	1.1	6.3	0	0.0	0.0
2011	38	41.3	66.8	8	8.7	25.0	1	1.1	6.0	0	0.0	0.0
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	36.8	46.4	7	9.2	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	40	42.1	65.0	11	11.6	24.5	2	2.1	10.4	0	0.0	0.0
2017	34	30.4	55.3	15	13.4	32.1	3	2.7	14.2	0	0.0	0.0
P for trend	-	-	0.901	-	-	0.488	-	-	-	-	-	-

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

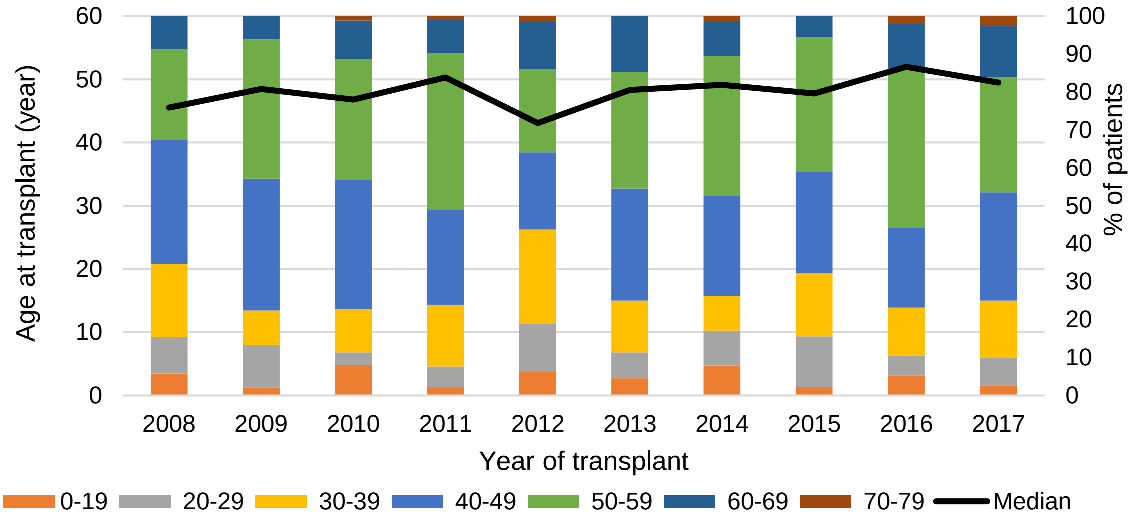
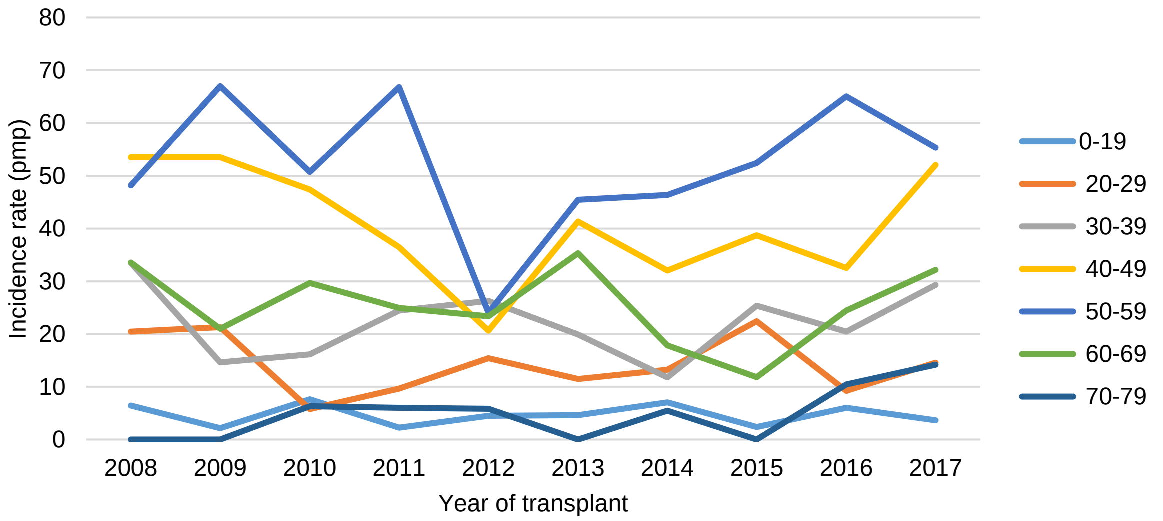
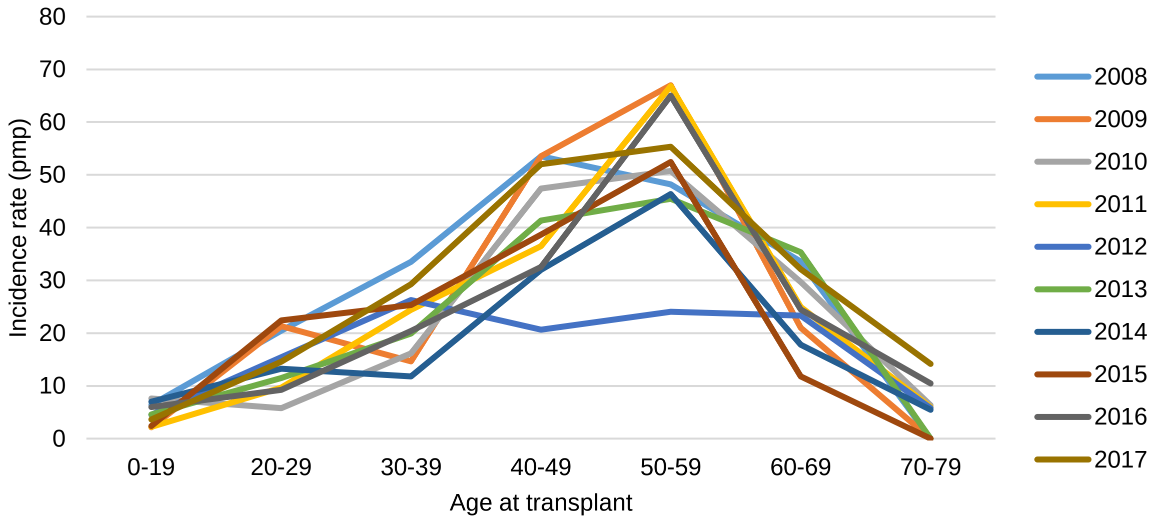


Figure 5.9.2b: Age-specific incidence rate (pmp) of kidney transplant across years



The CIR of kidney transplant increased with age until 59 years old (Figure 5.9.3). Beyond 59 years old, the CIR of transplant dropped with age.

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



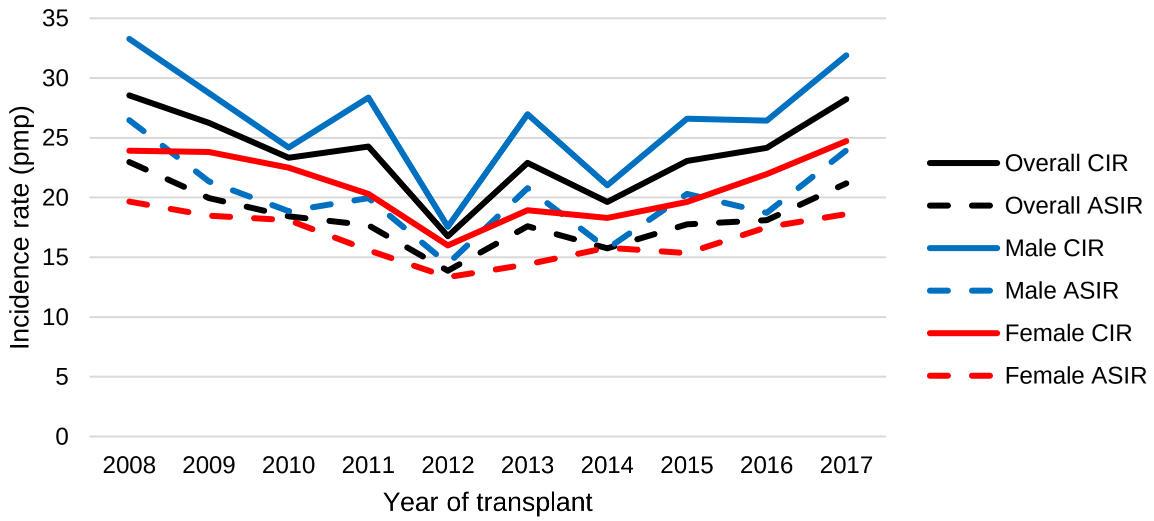
The ASIR of kidney transplant were consistently higher among men than women across the years (Table 5.9.3 and Figure 5.9.4. In 2017, the ASIR was 24.0 pmp and 18.6 pmp for men and women respectively. The ASIR for both genders fluctuated randomly over the years.

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

Male				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2008	60	57.7	33.3	26.5
2009	53	54.1	28.7	21.4
2010	45	51.1	24.2	18.9
2011	53	57.6	28.4	20.0
2012	33	51.6	17.6	14.5
2013	51	58.0	27.0	20.8
2014	40	52.6	21.0	15.7
2015	51	56.7	26.6	20.3
2016	51	53.7	26.4	18.7
2017	62	55.4	31.9	24.0
P for trend	-	-	0.796	0.600

Female				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2008	44	42.3	23.9	19.7
2009	45	45.9	23.8	18.5
2010	43	48.9	22.5	18.1
2011	39	42.4	20.3	15.6
2012	31	48.4	16.0	13.3
2013	37	42.0	18.9	14.4
2014	36	47.4	18.3	15.8
2015	39	43.3	19.6	15.3
2016	44	46.3	22.0	17.5
2017	50	44.6	24.7	18.6
P for trend	-	-	0.693	0.515

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

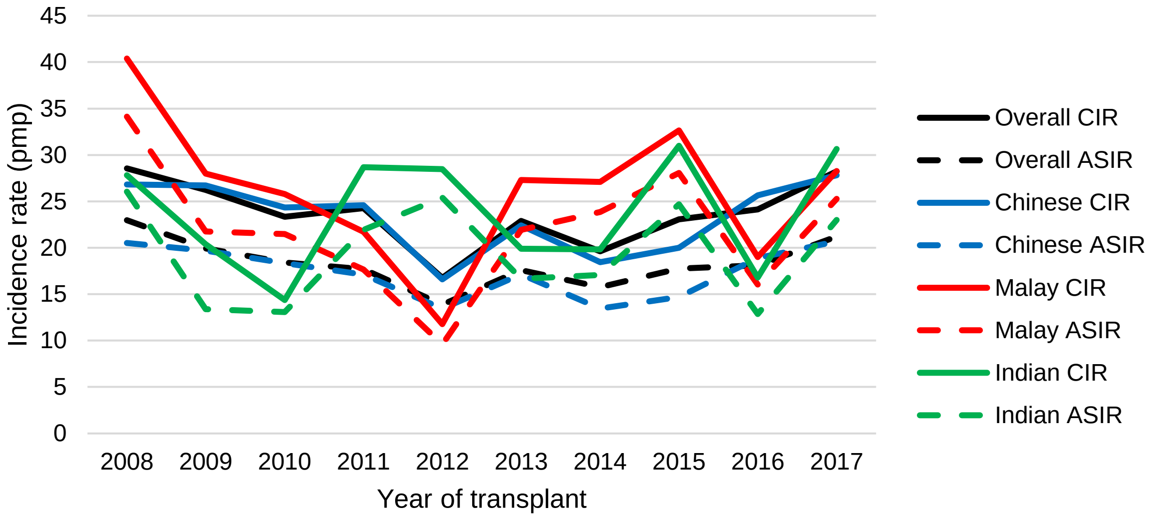


There was no ethnic group with distinctly or consistently higher or lower incidence rates of kidney transplant across the years (Table 5.9.4 and Figure 5.9.5). In 2017, the ASIR was 20.7 pmp, 25.3 pmp and 23.0 pmp for the Chinese, Malays and Indians respectively. The ASIR for the three ethnic groups fluctuated randomly over the years.

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

Chinese				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2008	73	70.2	26.8	20.5
2009	74	75.5	26.7	19.7
2010	68	77.3	24.3	18.3
2011	69	75.0	24.6	17.1
2012	47	73.4	16.6	13.4
2013	64	72.7	22.4	17.2
2014	53	69.7	18.4	13.5
2015	58	64.4	20.0	14.7
2016	75	78.9	25.7	18.9
2017	82	73.2	27.8	20.7
P for trend	-	-	0.669	0.586
Malay				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2008	20	19.2	40.4	34.1
2009	14	14.3	28.0	21.7
2010	13	14.8	25.8	21.5
2011	11	12.0	21.7	17.7
2012	6	9.4	11.8	9.6
2013	14	15.9	27.3	21.9
2014	14	18.4	27.1	23.8
2015	17	18.9	32.6	28.1
2016	10	10.5	19.0	16.0
2017	15	13.4	28.3	25.3
P for trend	-	-	0.622	0.798
Indian				
Year of transplant	**Number**	**%**	**CIR**	**ASIR**
2008	9	8.7	27.8	26.0
2009	7	7.1	20.4	13.4
2010	5	5.7	14.4	13.1
2011	10	10.9	28.7	21.9
2012	10	15.6	28.5	25.4
2013	7	8.0	19.9	16.7
2014	7	9.2	19.8	17.1
2015	11	12.2	31.0	24.7
2016	6	6.3	16.8	12.9
2017	11	9.8	30.7	23.0
P for trend	-	-	0.728	0.911

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



Unlike new patients on definitive dialysis (Table 5.4.6) where DN was the most common cause of CKD5, GN was the main cause of CKD5 among new kidney transplant patients (Table 5.9.5). The proportion of new kidney transplants with GN was 60.7% in 2017, while the proportion of new kidney transplants with DN was 16.1%. 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[8,9].

Table 5.9.5: Incidence number of kidney transplant by etiology

Year of transplant	DN		GN		Others	
	Number	%	Number	%	Number	%
2008	9	8.7	70	67.3	25	24.0
2009	19	19.4	61	62.2	18	18.4
2010	11	12.5	56	63.6	21	23.9
2011	9	9.8	58	63.0	25	27.2
2012	9	14.1	46	71.9	9	14.1
2013	8	9.1	55	62.5	25	28.4
2014	11	14.5	43	56.6	22	28.9
2015	18	20.0	49	54.4	23	25.6
2016	17	17.9	52	54.7	26	27.4
2017	18	16.1	68	60.7	26	23.2

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

Most of the new kidney transplants were done locally (79.5%) in 2017, with a higher contribution from deceased donors (43.8%) than living donors (35.7%). Transplants done overseas were not further stratified into living or deceased donor as the Ministry of Home Affairs does not track the death status of foreign donors.

Table 5.9.6: Incidence number of kidney transplant by location of nephrectomy and type of donor

Year of transplant	Local transplant				Overseas transplant	
	Living donor		Deceased donor			
	Number	%	Number	%	Number	%
2008	27	26.0	46	44.2	31	29.8
2009	28	28.6	41	41.8	29	29.6
2010	25	28.4	36	40.9	27	30.7
2011	31	33.7	36	39.1	25	27.2
2012	28	43.8	23	35.9	13	20.3
2013	35	39.8	34	38.6	19	21.6
2014	41	53.9	17	22.4	18	23.7
2015	40	44.4	32	35.6	18	20.0
2016	32	33.7	40	42.1	23	24.2
2017*	40	35.7	49	43.8	21	18.8

*There were two kidney transplants in 2017 where the transplant location was unknown.

5.10 Prevalence of kidney transplant

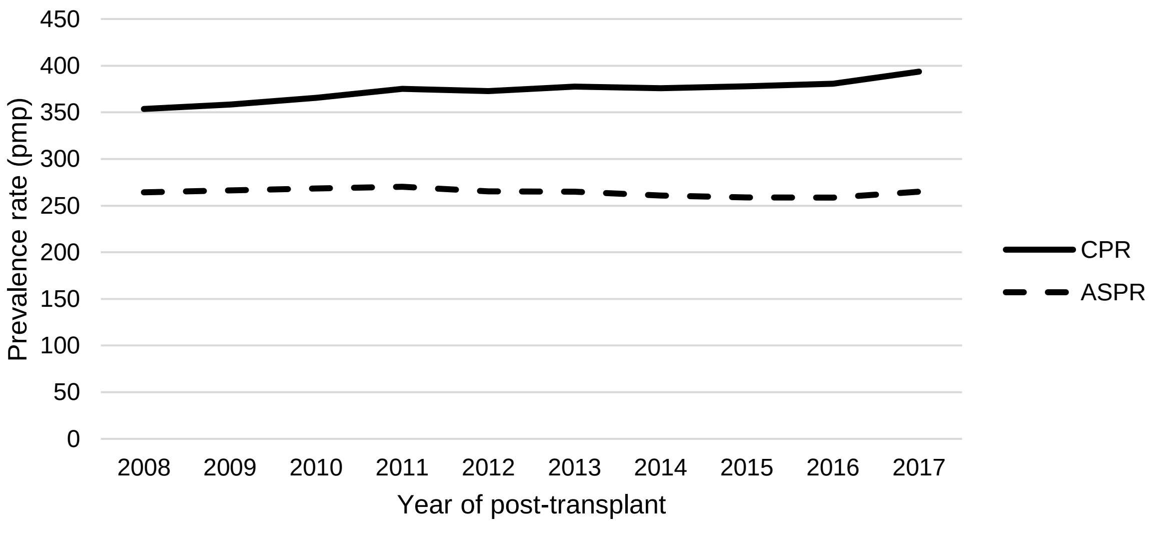
The prevalence rate in each year was computed by taking the cumulative number of surviving (existing and new) patients with kidney transplant in a year, divided by the number of Singapore residents in the same year. Patients (receiving the kidney) were categorized into 10-year age groups and age standardization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

Unlike the incidence trend of kidney transplant (Table 5.9.1 and Figure 5.9.1), the number of prevalent patients with kidney transplant increased consistently since 2008, with a significant rise in CPR (p<0.001) (Table 5.10.1 and Figure 5.10.1). However, the ASPR remained relatively stable, ranging between 258 pmp and 271 pmp during this period, implying that the rise in new patients undergoing kidney transplant was fairly similar to the drop in prevalent patients from those who died, after adjusting for age. The comparison between CPR and ASPR indicates that the rise prevalence is largely due to Singapore's ageing population.

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

Year of post-transplant	Number	CPR	ASPR
2008	1288	353.6	264.2
2009	1338	358.4	266.4
2010	1379	365.6	268.3
2011	1421	375.0	270.2
2012	1423	372.7	265.4
2013	1452	377.7	264.8
2014	1455	375.9	260.7
2015	1475	377.9	258.9
2016	1498	380.8	258.6
2017	1561	393.6	265.0
P for trend	-	<0.001	0.071

Figure 5.10.1: Prevalence rate (pmp) of kidney transplant



The majority of the prevalent kidney transplant patients were aged 50 to 69 years. In 2017, close to two-thirds of the prevalent kidney transplant patients were in this age band (Table 5.10.2).

The median age among prevalent kidney transplant patients increased linearly from 51.6 years in 2008 to 56.8 years in 2017 (Figure 5.10.2a).

The age distribution of prevalent kidney transplant patients shifted away from the 30-39, 40-49 and 50-59 age groups to the 0-19, 20-29, 60-69, 70-79 and 80+ age groups over the years (Figure 5.10.2b). The rise in CPR was especially fast for patients aged 70 to 79 years, whereby the CPR tripled within 10 years.

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
2008	18	1.4	19.3	43	3.3	88.0	135	10.5	226.1	373	29.0	587.1
2009	16	1.2	17.2	46	3.4	89.1	134	10.0	218.0	373	27.9	587.0
2010	18	1.3	19.6	44	3.2	84.6	124	9.0	200.5	358	26.0	565.5
2011	17	1.2	18.9	48	3.4	92.7	123	8.7	200.4	326	22.9	517.0
2012	16	1.1	18.1	52	3.7	100.2	117	8.2	192.1	304	21.4	482.8
2013	17	1.2	19.5	49	3.4	93.8	118	8.1	195.9	292	20.1	464.4
2014	19	1.3	22.2	53	3.6	100.1	108	7.4	181.7	272	18.7	435.5
2015	18	1.2	21.3	56	3.8	104.6	109	7.4	184.2	273	18.5	440.2
2016	20	1.3	23.9	57	3.8	105.4	103	6.9	175.3	277	18.5	450.7
2017	18	1.2	21.8	67	4.3	122.0	103	6.6	177.5	280	17.9	455.3
P for trend	-	-	0.006	-	-	<0.001	-	-	<0.001	-	-	<0.001
Year of post-transplant	**Age 50-59**			**Age 60-69**			**Age 70-79**			**Age 80+**		
	Number	**%**	**CPR**	**Number**	**%**	**CPR**	**Number**	**%**	**CPR**	**Number**	**%**	**CPR**
2008	476	37.0	917.9	219	17.0	816.3	23	1.8	164.1	1	0.1	16.6
2009	495	37.0	921.1	244	18.2	853.4	29	2.2	194.6	1	0.1	15.4
2010	533	38.7	965.9	264	19.1	870.7	35	2.5	221.9	3	0.2	43.4
2011	573	40.3	1007.7	288	20.3	898.6	43	3.0	257.6	3	0.2	41.0
2012	559	39.3	960.2	319	22.4	930.6	53	3.7	308.1	3	0.2	38.7
2013	556	38.3	936.2	358	24.7	972.6	59	4.1	335.0	3	0.2	36.5
2014	547	37.6	905.8	391	26.9	995.7	62	4.3	338.6	3	0.2	34.4
2015	529	35.9	867.0	409	27.7	967.1	76	5.2	413.4	5	0.3	53.5
2016	513	34.2	833.9	421	28.1	935.8	103	6.9	537.2	4	0.3	40.9
2017	508	32.5	826.7	458	29.3	981.5	121	7.8	572.2	6	0.4	59.2
P for trend	-	-	0.018	-	-	0.001	-	-	<0.001	-	-	0.009

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

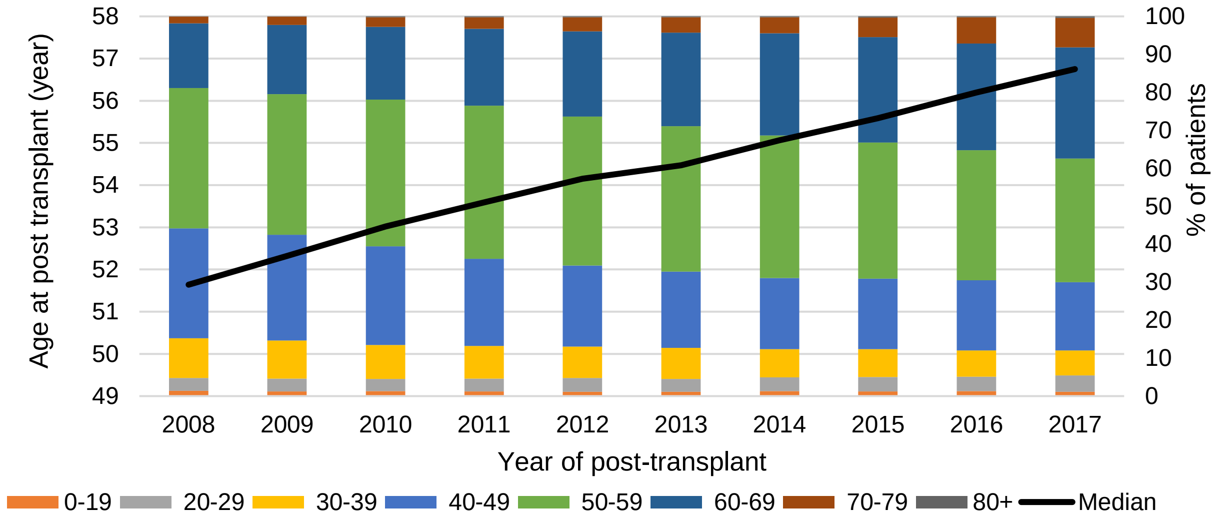
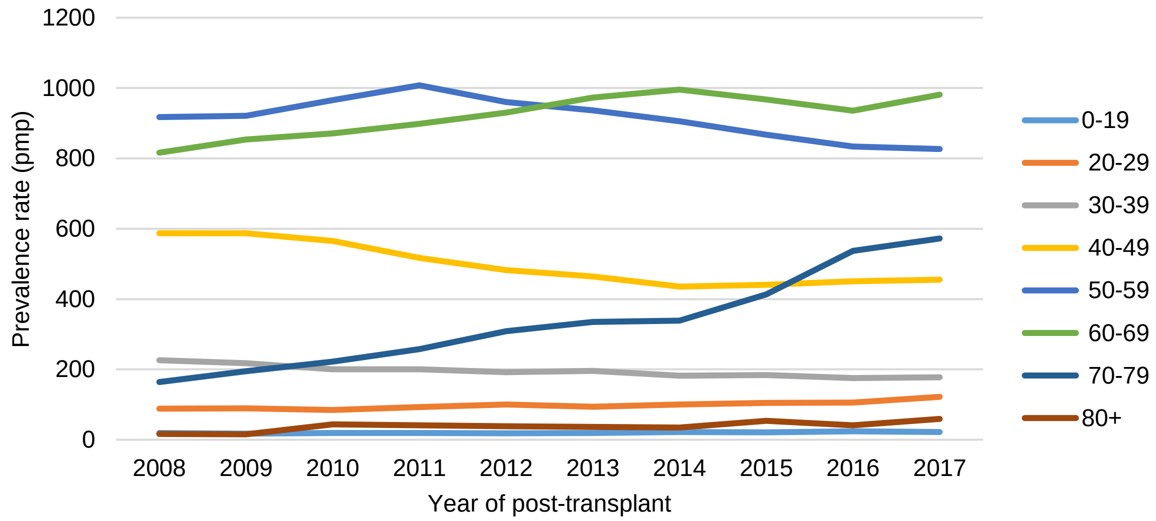
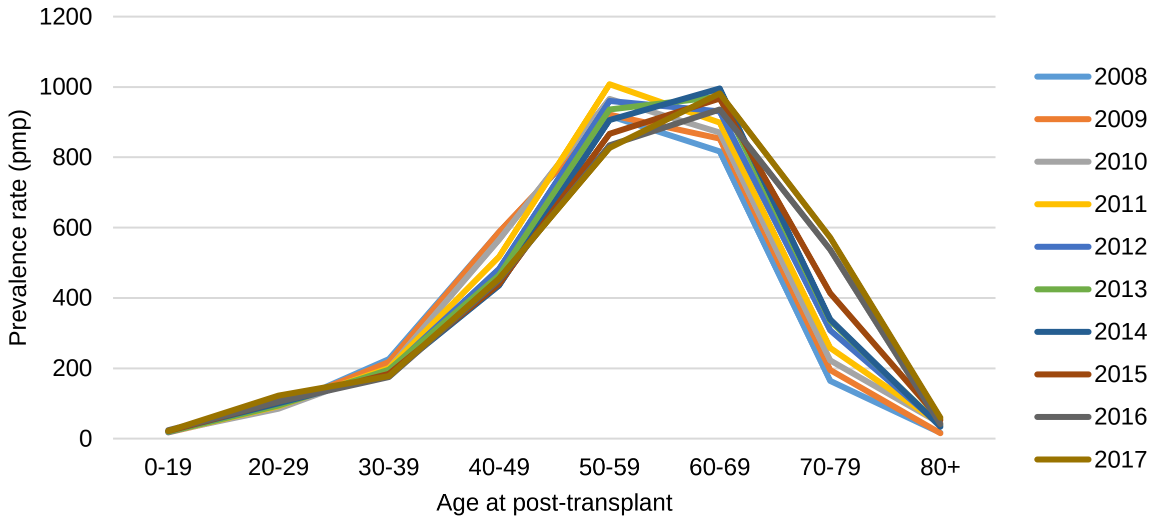


Figure 5.10.2b: Age-specific prevalence rate (pmp) of kidney transplant across years



Prior to 2013, the CPR of kidney transplant peaked at the 50-59 age group. However, the peak of the CPR shifted to the 60-69 age group from 2013 onwards (Figure 5.10.3).

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



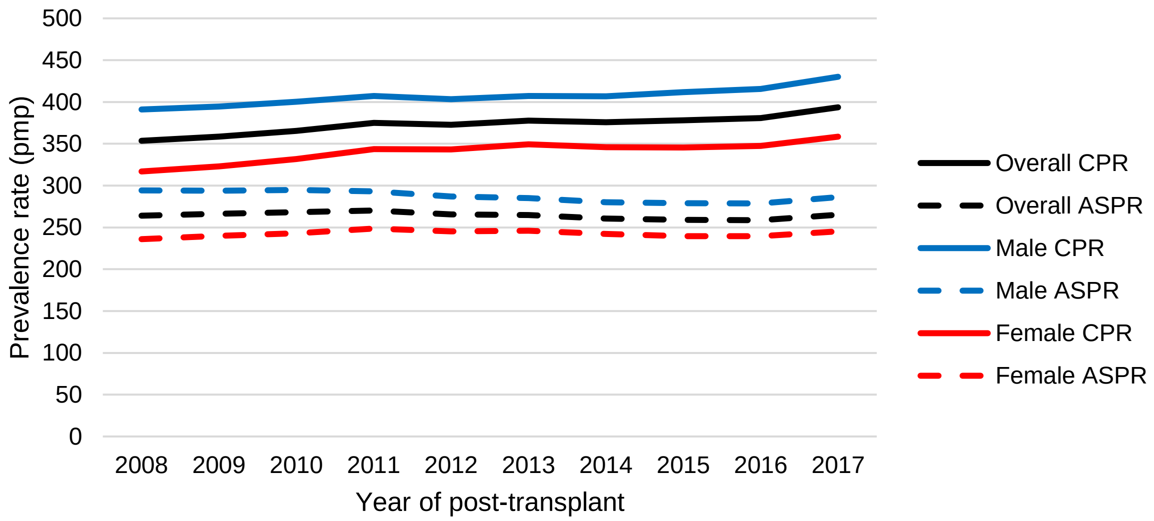
The ASPR of kidney transplant were consistently higher among men than women across the years (Table 5.10.3 and Figure 5.10.4). In 2017, the ASPR was 286.0 pmp and 245.4 pmp for men and women respectively. While the ASPR for men decreased significantly over the years (p=0.002), the ASPR for women remained relatively stable.

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

Male				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2008	705	54.7	391.0	294.1
2009	728	54.4	394.7	294.0
2010	745	54.0	400.3	294.8
2011	761	53.6	407.3	293.2
2012	758	53.3	403.2	287.1
2013	770	53.0	407.1	285.0
2014	774	53.2	406.9	280.2
2015	789	53.5	411.7	279.1
2016	802	53.5	415.6	278.7
2017	836	53.6	430.1	286.0
P for trend	-	-	<0.001	0.002

Female				
Year of post-transplant	Number	%	CPR	ASPR
2008	583	45.3	316.9	236.0
2009	610	45.6	322.9	240.0
2010	634	46.0	331.8	242.9
2011	660	46.4	343.6	248.6
2012	665	46.7	343.2	245.2
2013	682	47.0	349.2	246.1
2014	681	46.8	346.0	242.4
2015	686	46.5	345.4	239.7
2016	696	46.5	347.3	239.7
2017	725	46.4	358.5	245.4
P for trend	-	-	<0.001	0.506

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

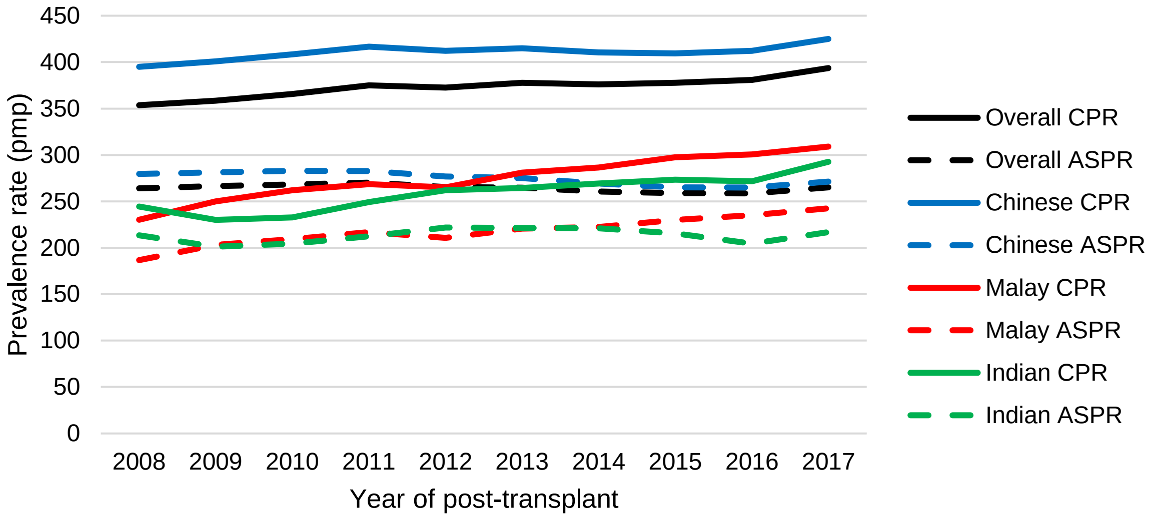


The ASPR of kidney transplant were consistently higher among the Chinese than the Malays and Indians across the years (Table 5.10.4 and Figure 5.10.5). While the ASPR for the Chinese decreased significantly from 279.7 pmp in 2008 to 271.2 pmp in 2017 (p=0.002), the ASPR for the Malays increased significantly from 186.7 pmp in 2008 to 242.5 pmp in 2017 (p<0.001) and the ASPR for the Indians fluctuated between 201 pmp and 222 pmp over the years.

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

Chinese				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2008	1075	83.5	395.0	279.7
2009	1110	83.0	400.7	281.4
2010	1141	82.7	408.4	282.9
2011	1170	82.3	416.6	282.7
2012	1167	82.0	412.1	276.9
2013	1184	81.5	414.9	275.1
2014	1180	81.1	410.5	269.3
2015	1187	80.5	409.3	265.3
2016	1205	80.4	412.2	264.9
2017	1253	80.3	425.0	271.2
P for trend	-	-	0.012	0.002
Malay				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2008	114	8.9	230.2	186.7
2009	125	9.3	250.0	203.1
2010	132	9.6	261.9	209.1
2011	136	9.6	268.6	216.8
2012	135	9.5	265.0	210.9
2013	144	9.9	280.9	220.8
2014	148	10.2	286.5	222.5
2015	155	10.5	297.5	230.1
2016	158	10.5	300.4	235.1
2017	164	10.5	309.0	242.5
P for trend	-	-	<0.001	<0.001
Indian				
Year of post-transplant	**Number**	**%**	**CPR**	**ASPR**
2008	79	6.1	244.4	213.5
2009	79	5.9	230.1	201.2
2010	81	5.9	232.8	204.5
2011	87	6.1	249.4	212.5
2012	92	6.5	262.1	221.8
2013	93	6.4	264.6	221.2
2014	95	6.5	269.1	221.2
2015	97	6.6	273.3	215.6
2016	97	6.5	271.8	204.4
2017	105	6.7	292.6	216.9
P for trend	-	-	<0.001	0.360

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



The proportion of prevalent kidney transplant patients with DN was lower than those with GN, with fewer than 10% of them having DN and about 70% having GN in the past decade (Table 5.10.5). However, while the proportion of prevalent transplant patients with DN increased consistently since 2008, those with GN decreased. These imply that although more prevalent patients with GN received transplant than those with DN, the gap between them narrowed over the years.

Table 5.10.5: Prevalence number of kidney transplant by etiology

Year of post-transplant	DN		GN		Others	
	Number	%	Number	%	Number	%
2008	86	6.7	928	72.0	274	21.3
2009	96	7.2	964	72.0	278	20.8
2010	103	7.5	984	71.4	292	21.2
2011	106	7.5	1010	71.1	305	21.5
2012	112	7.9	1011	71.0	300	21.1
2013	115	7.9	1028	70.8	309	21.3
2014	121	8.3	1019	70.0	315	21.6
2015	133	9.0	1022	69.3	320	21.7
2016	140	9.3	1032	68.9	326	21.8
2017	150	9.6	1071	68.6	340	21.8

Most of the prevalent kidney transplants were done locally (71.8%) in 2017, with a higher contribution from deceased donors (39.3%) than living donors (32.5%). Transplants done overseas were not further stratified into living or deceased donor as the Ministry of Home Affairs does not track the death status of foreign donors.

Table 5.10.6: Prevalence number of kidney transplant by type of donor

Year of post-transplant	Local transplant				Overseas transplant	
	Living donor		Deceased donor			
	Number	%	Number	%	Number	%
2008	329	25.5	568	44.1	391	30.4
2009	350	26.2	583	43.6	405	30.3
2010	363	26.3	592	42.9	424	30.7
2011	388	27.3	602	42.4	431	30.3
2012	404	28.4	589	41.4	430	30.2
2013	429	29.5	591	40.7	432	29.8
2014	455	31.3	571	39.2	429	29.5
2015	480	32.5	570	38.6	425	28.8
2016	486	32.4	585	39.1	427	28.5
2017	508	32.5	613	39.3	440	28.2

5.11 Survival of kidney transplant

Patient survival: the unadjusted survival rate and survival duration of new kidney transplant patients were estimated using the Kaplan-Meier method in Table 5.11.1 to 5.11.10. The event was defined as all-cause death. Patients were censored if they did not die by 28 February 2018, the date until which the death status of all patients registered in the SRR were updated. Median survival duration is indicated as "not reached (NR)" if more than half of the patients were still alive as of 28 February 2018.

Graft survival: the unadjusted survival rate and survival duration of new kidney transplant were estimated using the Kaplan-Meier method in Table 5.11.1 to 5.11.10. The 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 28 February 2018. 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 28 February 2018.

Cox regression model was used to adjust for the effects of potential confounders on the survival of patients in Table 5.11.11 and 5.11.12.

Grafts that stopped functioning within 30 days were excluded from this section.

Graft survival were high at 97.2%, 88.9% and 75.5% for one-, five- and ten-year post-transplant (Table 5.11.1). Patient survival was even higher and outperformed patients on dialysis (Table 5.7.1).

Table 5.11.1: Survival of kidney transplant by outcome

	Graft	Patient
1-year survival (%)	97.2	98.2
5-year survival (%)	88.9	93.4
10-year survival (%)	75.5	85.4
Median survival (years)	NR	NR

Table 5.11.2 excludes kidney transplants done overseas as the Ministry of Home Affairs does not track the death status of foreign donors. Survival was significantly better among transplants from living donors than deceased donors (graft: p<0.001, patient: p=0.001).

Table 5.11.2: Survival of kidney transplant by type of local donor and outcome

	Graft		Patient	
	Living	Deceased	Living	Deceased
1-year survival (%)	99.2	95.8	99.2	97.4
5-year survival (%)	94.5	85.1	96.1	91.6
10-year survival (%)	83.1	68.1	90.0	82.0
Median survival (years)	NR	16.2	NR	NR

Younger patients aged below 60 years had significantly better survival than older patients aged 60 years or older (graft: p=0.013, patient: p<0.001) (Table 5.11.3).

Table 5.11.3: Survival of kidney transplant by age group and outcome

	Age <60 years		Age ≥60 years	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.5	98.4	94.3	95.0
5-year survival (%)	89.3	93.9	84.6	87.9
10-year survival (%)	76.0	86.3	70.5	74.0
Median survival (years)	NR	NR	13.4	13.4

Survival was fairly similar between the two genders (Table 5.11.4).

Table 5.11.4: Survival of kidney transplant by gender and outcome

	Male		Female	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.0	98.1	97.5	98.3
5-year survival (%)	88.2	93.8	89.8	92.9
10-year survival (%)	73.9	85.6	77.6	85.3
Median survival (years)	NR	NR	NR	NR

Although the Chinese had significantly better graft survival than the Malays and Indians (p=0.002), patient survival was fairly similar across the three ethnic groups (Table 5.11.5).

Table 5.11.5: Survival of kidney transplant by ethnicity and outcome

	Chinese		Malay		Indian	
	Graft	Patient	Graft	Patient	Graft	Patient
1-year survival (%)	97.3	98.3	96.4	97.4	97.6	98.4
5-year survival (%)	90.0	93.7	84.7	93.0	82.8	90.1
10-year survival (%)	77.6	85.4	67.9	86.5	61.0	81.6
Median survival (years)	NR	NR	15.1	NR	16.7	NR

Patients without DN had significantly better survival than those with DN (graft and patient: p<0.001) (Table 5.11.6).

Table 5.11.6: Survival of kidney transplant by etiology and outcome

	Non-DN		DN	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.3	98.3	96.2	97.1
5-year survival (%)	89.9	94.4	80.8	85.5
10-year survival (%)	76.8	86.7	65.9	75.3
Median survival (years)	NR	NR	13.0	15.5

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

Table 5.11.7: Survival of kidney transplant by presence of IHD and outcome

	No IHD		IHD	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.3	98.5	97.2	97.2
5-year survival (%)	90.0	94.7	83.3	86.7
10-year survival (%)	76.7	87.0	69.2	76.8
Median survival (years)	NR	NR	13.9	15.5

Patients without CVD had significantly better survival than those with CVD (graft: p=0.010, patient: p=0.001) (Table 5.11.8).

Table 5.11.8: Survival of kidney transplant by presence of CVD and outcome

	No CVD		CVD	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.7	98.5	87.4	92.1
5-year survival (%)	89.4	93.8	83.8	90.3
10-year survival (%)	76.0	85.9	69.4	79.6
Median survival (years)	NR	NR	11.2	14.8

Although graft survival was fairly similar between patients with PVD and those without PVD, patients without PVD had significantly better patient survival than those with PVD (p=0.019) (Table 5.11.9).

Table 5.11.9: Survival of kidney transplant by presence of PVD and outcome

	No PVD		PVD	
	Graft	Patient	Graft	Patient
1-year survival (%)	97.4	98.3	92.2	96.2
5-year survival (%)	89.3	93.9	82.5	86.5
10-year survival (%)	75.9	85.9	74.2	77.9
Median survival (years)	NR	NR	12.9	12.9

Patients without cancer seemed to have better survival than those with cancer (Table 5.11.10). However, the survival difference between patients with and without cancer was not statistically significant due to the small number of patients with cancer and small number of patients who died regardless of cancer status.

Table 5.11.10: Survival of kidney transplant by presence of cancer and outcome

	No cancer		Cancer	
	Graft	**Patient**	**Graft**	**Patient**
1-year survival (%)	97.6	98.6	95.7	95.7
5-year survival (%)	90.1	94.6	81.0	85.3
10-year survival (%)	76.6	86.6	66.8	74.9
Median survival (years)	NR	NR	NR	NR

Table 5.11.11 excludes kidney transplants done overseas as the Ministry of Home Affairs does not track the death status of foreign donors. Transplant from deceased donor, old age, DN and IHD were significant predictors of death among transplant patients.

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
Donor type			
Local living	Reference		
Local deceased	2.20	1.51-3.21	<0.001
Age group			
<60 years	Reference		
≥60 years	2.44	1.15-5.17	0.020
Gender			
Male	Reference		
Female	1.02	0.74-1.41	0.888
Ethnicity			
Chinese	Reference		
Malay	0.99	0.63-1.54	0.951
Indian	1.34	0.78-2.31	0.288
Etiology			
Non-DN	Reference		
DN	2.56	1.44-4.53	0.001
IHD			
No	Reference		
Yes	1.93	1.24-3.00	0.004
CVD			
No	Reference		
Yes	1.85	0.83-4.16	0.135
PVD			
No	Reference		
Yes	1.79	0.68-4.73	0.237
Cancer			
No	Reference		
Yes	1.95	0.79-4.84	0.147

Table 5.11.12 includes dialysis patients but excludes kidney transplants done overseas. Dialysis without transplant, old age, DN, IHD, CVD, PVD and cancer were significant predictors 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
Transplant			
Dialysis	Reference		
Transplant from local living donor	0.17	0.13-0.23	<0.001
Transplant from local deceased donor	0.33	0.27-0.39	
Age group			
<60 years	Reference		<0.001
≥60 years	1.81	1.73-1.90	
Gender			
Male	Reference		0.412
Female	1.02	0.97-1.07	
Ethnicity			
Chinese	Reference		
Malay	0.94	0.89-0.99	0.032
Indian	0.97	0.89-1.06	0.465
Etiology			
Non-DN	Reference		<0.001
DN	1.63	1.55-1.72	
IHD			
No	Reference		<0.001
Yes	1.45	1.38-1.52	
CVD			
No	Reference		<0.001
Yes	1.33	1.26-1.40	
PVD			
No	Reference		<0.001
Yes	1.47	1.38-1.56	
Cancer			
No	Reference		<0.001
Yes	1.39	1.28-1.51	

6. CONCLUSION

Although survival among dialysis patients has improved over the years, on top of the direct costs from medical expenses, there are also lifestyle changes required to accommodate the treatment. Although kidney transplant is a good alternative treatment to dialysis as transplant patients have better survival and quality of life with less disruptions to their daily living compared to dialysis patients who have to set aside several hours for each dialysis session, the combined (living and deceased) kidney transplant rate is much lower than the demand, which is expected to increase in future with an ageing population and concomitant increase in chronic diseases in Singapore. It is therefore important for individuals who have not been diagnosed with CKD to take preventive action.

One can reduce his/her chances of developing CKD by adopting a healthy lifestyle, such as eating all food in moderation and opting for healthier products, exercising and maintaining a healthy weight, avoiding smoking, going for health screening and follow-ups, and controlling blood pressure, cholesterol and glucose levels well. 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.