Singapore Renal Registry
Annual Report 2016

National Registry of Diseases Office
(NRDO)

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Acknowledgement

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Contents

1 GLOSSARY

ASR	*Age-Standardised Rate*
BSA	*Body Surface Area*
CKD5	*Chronic Kidney Disease Stage 5*
CI	*Confidence Interval*
CR	*Crude Rate*
DN	*Diabetic Nephropathy*
eGFR	*Estimated glomerular filtration rate*
ESA	*Erythropoiesis Stimulating Agents*
ESRD	*End Stage Renal Disease*
GN	*Glomerulonephritis*
HD	*Haemodialysis*
HYP	*Hypertension*
iPTH	*Intact Parathyroid Hormone*
MOH	*Ministry of Health*
PD	*Peritoneal Dialysis*
PMP	*Per million population*
PTE	*Private Dialysis Centre*
RH	*Restructured Hospital*
SRR	*Singapore Renal Registry*
TX	*Transplant*
URR	*Urea Reduction Ratio*
USRDS	*United States Renal Data System*
VWO	*Voluntary Welfare Organisation*

2 INTRODUCTION

Kidney failure is a worldwide epidemic[1]; and diabetes is a leading cause of renal impairment. In Singapore, 2.3% of the residents aged between 18 and 69 years old had renal impairment as defined by eGFR less than 60 mL/min/1.73m^2. The National Health Survey 2010 also showed that the crude prevalence of diabetes mellitus increased from 8.6% in 1992 to 11.3% in 2010[2]. In addition, 1 in 3 diabetics were unaware that they had diabetes. Among the diabetics who were aware of their condition, 1 in 3 had poor diabetic control[3]. This increase in diabetes is further compounded by ageing of the population which accelerates the increase in kidney failure[4]. The median age of the Singapore resident population increased from 34.0 years in 2000 to 40.0 years in 2016. Correspondingly, the percentage of the population aged 65 years and above increased from 7.2% in 2000 to 11.8% in 2016[5].

Following the progression of kidney disease, patients with renal impairment are at higher risk of progressing to Chronic Kidney Diseases Stage 5 (CKD5). CKD5 is a stage of kidney failure when either the GFR (corrected to the body surface area of 1.73m^2) is less than 15 ml/min. CKD5 patients are generally managed through renal replacement therapy, such as dialysis or transplant, to prolong their long-term survival.

With the increase in the number of CKD5 patients, the economic burden due to kidney failure in Singapore is expected to escalate.

This report is intended to provide epidemiological trends on CKD5 patients on dialysis and renal transplantation for the period from 1999 to 2016.

3 METHODOLOGY

CKD5 includes patients who are approaching End-stage Renal Disease (ESRD) and patients who have reached ESRD. In most registry data, only patients who are initiated on dialysis are captured; in some as in the USRDS, only data on those

[1] Mallamaci. Highlights of the 2016 ERA-EDTA congress: chronic kidney disease, hypertension. Nephrol. Dial. Transplant (2016)
[2] National Health Survey 2010
[3] https://www.moh.gov.sg/content/dam/moh_web/PressRoom/Highlights/2016/cos/factsheets/COS_Factsheet%20-%20Diabetes.pdf. Accessed on 30 Nov 2016
[4] Ayodele and Alebiosu. Burden of chronic kidney disease: an international perspective. Adv chronic Kidney Dis. 2010; 17(3): 215-24
[5] https://www.singstat.gov.sg/docs/default-source/default-document-library/publications/publications_and_papers/population_and_population_structure/population2016.pdf Accessed on 8 July 2016

surviving 90 days are captured. However, these methods may not entirely reflect accurately the burden of kidney failure in the nation and may underestimate the workload of healthcare professionals, especially the nephrologists, who manage this group of patients. As such, in 1999, the Registry started capturing data of cases classified as having CKD5 i.e. patients initiating on renal replacement therapy or all patients with serum creatinine ≥ 10 mg/dl or 880 µmol/L.

In year 2007 the Singapore General Hospital, which contributes about 50% of the new CKD5 cases, started to provide the Registry with listing of patients with estimated glomerular filtration rate (eGFR) < 15 ml/min (corrected for BSA 1.73m^2). This was followed by the National University Hospital in year 2009, and the remaining restructured hospitals in year 2010 when the subsidiary legislation covering CKD5 was put in place by MOH.

Data source for case finding

The main source of data came from the annual collection of data from restructured hospitals, dialysis centres, transplant centres and private nephrology clinics in Singapore (Table 3.1). Since 1999, case finding for CKD5 was guided by serum creatinine ≥ 10 mg/dl or 880 µmol/L, or if patients started renal replacement therapy. Since 2010, this was subsequently changed to serum creatinine ≥ 500 µmol/L, or eGFR < 15 ml/min (corrected for BSA 1.73m^2), or if patients started renal replacement therapy at the national level.

Table 3.1: List of Participating Centres and Prevalent Patients as of 31 Dec 2015 and 2016

	2015			2016		
Restructured Hospitals and Affiliated Dialysis Centres	**HD**	**PD**	**TX**	**HD**	**PD**	**TX**
Singapore General Hospital	19	300	808	7	331	793
Alexandra Hospital	0	0	0	1	0	0
Tan Tock Seng Renal Centre	8	101	30	4	113	30
Changi General Hospital	5	57	2	1	61	2
Khoo Teck Puat Hospital	1	55	0	3	82	0
Ng Teng Fong General Hospital	0	31	0	0	33	0
National University Hospital	5	133	447	4	162	477
NUH Dialysis Centre	58	0	0	55	0	0
NUH Renal Centre	14	0	0	20	0	0
Shaw NKF - NUH Children's Kidney Centre	4	17	42	5	14	43
Sub-total	**114**	**694**	**1329**	**100**	**796**	**1345**
Voluntary Welfare Organisations	**HD**	**PD**	**TX**	**HD**	**PD**	**TX**
Hong Leong - NKF Dialysis Centre (Aljunied Crescent)	100	0	0	103	0	0
IFPAS - NKF Dialysis Centre (Serangoon)	104	0	0	104	0	0
Japan Airline - NKF Dialysis Centre (Ang Mo Kio I)	126	0	0	121	0	0
Kwan Im Thong Hood Cho Temple - NKF Dialysis Centre (Kolam Ayer)	76	0	0	112	0	0
Kwan Im Thong Hood Cho Temple - NKF Dialysis Centre (Simei)	152	0	0	154	0	0
Le Champ - NKF Dialysis Centre (Blk 639 Yishun St 61)	112	0	0	110	0	0
Leong Hwa Chan Si Temple - NKF Dialysis Centre (Teck Whye)	104	0	0	106	0	0
New Creation Church - NKF Dialysis Centre	91	0	0	89	0	0
NKF Bukit Panjang Dialysis Centre	0	0	0	90	0	0
NKF Dialysis Centre (Blk 365 Woodlands II)	106	0	0	108	0	0
NKF Hougang Punggol Dialysis Centre	102	0	0	110	0	0
Ntuc Income - NKF Dialysis Centre (Bukit Batok)	88	0	0	87	0	0
Ntuc/Singapore Pools - NKF Dialysis Centre (Tampines)	127	0	0	128	0	0
Pei Hwa Foundation - NKF Dialysis Centre (Ang Mo Kio)	123	0	0	121	0	0
Saf - NKF Dialysis Centre (Clementi)	112	0	0	107	0	0
Saf - NKF Dialysis Centre (Hong Kah)	96	0	0	97	0	0
Sakyadhita -NKF Dialysis Centre (Upper Boon Keng)	91	0	0	96	0	0
Scal - NKF Dialysis Centre (Yishun)	0	0	0	75	0	0
Sheng Hong Temple - NKF Dialysis Centre (Jurong West)	117	0	0	113	0	0
Sia - NKF Dialysis Centre (Toa Payoh)	79	0	0	82	0	0
Singapore Buddhist Welfare Services - NKF Dialysis Centre (Hougang)	155	0	0	157	0	0
Singapore Pools - NKF Dialysis Centre (Bedok)	106	0	0	103	0	0
Tampines Chinese Temple - NKF Dialysis Centre (Pasir Ris)	75	0	0	75	0	0
Tay Choon Hye - NKF Dialysis Centre (Kim Keat)	113	0	0	116	0	0
The Singapore Buddhist Lodge - NKF Dialysis Centre (128 Bukit Merah View)	51	0	0	73	0	0
The Sirivadhanabhakdi Foundation NKF Dialysis Centre (JW2)	0	0	0	95	0	0
Thong Teck Sian Tong Lian Sin Sia - NKF Dialysis Centre (Woodlands)	116	0	0	114	0	0
Toa Payoh Seu Teck Sean Tong - NKF Dialysis Centre (Yishun)	73	0	0	76	0	0
Western Digital - NKF Dialysis Centre (Ang Mo Kio)	156	0	0	148	0	0
Woh Hup - NKF Dialysis Centre (Ghim Moh)	113	0	0	105	0	0
Wong Sui Ha Edna - NKF Dialysis Centre	128	0	0	122	0	0
KDF - Bishan Centre	95	0	0	92	0	0
KDF - Kreta Ayer (HD)	71	0	0	70	0	0
KDF - Ghim Moh Centre (HD)	80	0	0	78	0	0
KDF - Ghim Moh Centre (PD)	0	34	0	0	25	0
Peoples' Dialysis Centre	98	0	0	92	0	0
Sub-total	**3336**	**34**	**0**	**3629**	**25**	**0**

Private Dialysis Centres/ Clinics	HD	PD	TX	HD	PD	TX
Advance Dialysis Services Pte Ltd	18	0	0	20	0	0
Advance Renal Care (Novena)	6	0	0	7	0	0
Advance Renal Therapy	1	0	0	0	0	0
Aegis Dialysis Centre	0	0	0	11	0	0
Aisa Renal Care Mt Elizabeth Pte Ltd	18	0	0	23	0	0
Arca (Farrer Park) Dialysis Pte Ltd	7	0	0	15	0	0
Asia Kidney Dialysis Centre (Bedok)	32	0	0	35	0	0
Asia Kidney Dialysis Centre (Jurong)	24	0	0	21	0	0
Asia Kidney Dialysis Centre (Teck Whye)	25	0	0	27	0	0
Asia Kidney Dialysis Centre (Tp)	62	0	0	55	0	0
Asia Kidney Dialysis Centre (Tpy)	50	0	0	42	0	0
B. Braun Dialysis Centre (East Coast)	0	0	0	8	0	0
B.Braun Dialysis Centre (Ang Mo Kio)	20	0	0	35	0	0
Econ Advance Renal Care (Yung Kuang)	0	0	0	3	0	0
Fresenius Medical Care (Teck Whye) Dialysis Clinic	27	0	0	37	0	0
Fresenius Medical Care Ang Mo Kio Dialysis Clinic (Blk 422)	53	0	0	55	0	0
Fresenius Medical Care Ang Mo Kio Dialysis Clinic (Blk 443)	43	0	0	44	0	0
Fresenius Medical Care Bedok North Dialysis Clinic (Blk 527)	20	0	0	20	0	0
Fresenius Medical Care Bedok Reservoir Dialysis Clinic (Blk 744)	66	0	0	66	0	0
Fresenius Medical Care Bukit Batok Dialysis Clinic (Blk 213)	41	0	0	36	0	0
Fresenius Medical Care Bukit Merah Dialysis Clinic (Blk 161)	45	0	0	51	0	0
Fresenius Medical Care Clementi Dialysis Clinic	40	0	0	43	0	0
Fresenius Medical Care Hougang Dialysis Clinic (Blk 620)	46	0	0	50	0	0
Fresenius Medical Care Jurong Boon Lay Dialysis Clinic (Blk 353)	38	0	0	39	0	0
Fresenius Medical Care Jurong East Central Dialysis Clinic (Blk 104)	59	0	0	67	0	0
Fresenius Medical Care Jurong East Dialysis Clinic (Blk 326)	42	0	0	45	0	0
Fresenius Medical Care Jurong West Dialysis Clinic (Blk 414)	41	0	0	0	0	0
Fresenius Medical Care Katong Dialysis Clinic	41	0	0	42	0	0
Fresenius Medical Care Kembangan Dialysis Clinic	61	0	0	52	0	0
Fresenius Medical Care Khatib Dialysis Clinic	0	0	0	12	0	0
Fresenius Medical Care Kovan Dialysis Clinic	56	0	0	66	0	0
Fresenius Medical Care Lucky Plaza Dialysis Clinic	11	1	0	6	1	0
Fresenius Medical Care Marsiling Dialysis Clinic	48	0	0	47	0	0
Fresenius Medical Care Napier Dialysis Clinic	28	1	0	26	0	0
Fresenius Medical Care Serangoon Dialysis Clinic	40	0	0	0	0	0
Fresenius Medical Care Tampines Dialysis Clinic (Blk 107)	57	0	0	52	0	0
Fresenius Medical Care Tanglin Dialysis Clinic	49	0	0	40	0	0
Fresenius Medical Care Toa Payoh Dialysis Clinic (Blk 92)	47	0	0	40	0	0
Fresenius Medical Care Upper Serangoon Dialysis Clinic	29	0	0	47	0	0
Fresenius Medical Care Whampoa Dialysis Clinic	52	0	0	47	0	0
Fresenius Medical Care Yishun Dialysis Clinic (Blk 236)	39	0	0	38	0	0
Fresenius Medical Care Yishun Ring Dialysis Clinic	47	0	0	31	0	0
Immanuel Dialysis Centre (Mayflower) Pte Ltd	16	0	0	14	0	0
Immanuel Dialysis Centre Pte Ltd (Ang Mo Kio)	29	0	0	28	0	0
Immanuel Dialysis Centre Pte Ltd (Mt Alvernia)	33	1	0	32	1	0
Immanuel Dialysis Centre Pte Ltd (Woodlands)	27	0	0	25	0	0
Immanuel Dialysis Centre Pte Ltd (Yishun)	28	0	0	21	0	0
Kidneycare Dialysis Centre @ Pasir Ris	43	0	0	51	0	0
Kidneycare Dialysis Centre @ Yishun	7	0	0	18	0	0
Pacific Advance Renal Care (Fajar)	0	0	0	11	0	0
Pacific Advance Renal Care (Seng Kang)	17	0	0	30	0	0
Pacific Advance Renal Care Pte Ltd (Punggol Way)	15	0	0	28	0	0

Pacific Advance Renal Care Pte Ltd (Tampines)	2	0	0	16	0	0
Pacific Advance Renal Care Pte Ltd (Woodlands)	17	0	0	29	0	0
Raffles Dialysis Centre	6	0	0	5	0	0
Renal & Dialysis Clinic (S) Pte Ltd (Deport Road)	13	0	0	0	0	0
Renal Health Pte Ltd	58	0	0	64	0	0
Renal Life (Alexandra) Dialysis Centre Pte Ltd	9	0	0	15	0	0
Renal Life (Hougang) Dialysis Centre Pte Ltd	25	0	0	18	0	0
Renal Life (W) Dialysis Centre Pte Ltd (Blk 207 Bukit Batok)	32	0	0	32	0	0
Renal Life Dialysis Centre Pte Ltd (Blk 463 Jurong West)	27	0	0	21	0	0
Renal Life(Pioneer) Dialysis Centre Pte Ltd	18	0	0	23	0	0
Renal Team Dialysis Centre Yishun	0	0	0	8	0	0
Renalteam Dialysis Centre - Ang Mo Kio	33	0	0	24	0	0
Renalteam Dialysis Centre - Bedok	39	0	0	40	0	0
Renalteam Dialysis Centre - Bukit Merah	13	0	0	31	0	0
Renalteam Dialysis Centre - Jurong East	23	0	0	34	0	0
Renalteam Dialysis Centre - Ren Ci Community Hospital	22	0	0	25	0	0
Renalteam Dialysis Centre - Tampines	31	0	0	36	0	0
Renalteam Dialysis Centre - Woodland	37	0	0	34	0	0
Centre For Kidney Disease Pte Ltd (Lucky Plaza)	0	0	38	0	0	43
Grace Lee Renal And Medical Clinic Pte Ltd	0	0	10	0	0	10
Kidney & Medical Centre	0	0	5	0	0	5
Ku Kidney & Medical Centre	0	0	22	0	0	21
Mount Elizabeth Hospital	0	0	2	0	0	0
Raffles Hospital	0	0	3	0	0	3
Roger Kidney Clinic	0	0	4	0	0	4
Stephew Chew Centre For Kidney Disease And Hypertension (MAH)	0	0	19	0	0	19
Stephew Chew Centre For Kidney Disease And Hypertension (MEH)	0	0	5	0	0	4
The Kidney Clinic Pte Ltd	0	0	9	0	0	13
The Singapore Clinic For Kidney Diseases	0	0	5	0	0	4
Wu Nephrology & Medical Clinic (Wu Medical Clinic Pte Ltd)	0	0	23	0	0	28
Sub-total	**2049**	**3**	**145**	**2114**	**2**	**154**
GRAND TOTAL	**5499**	**731**	**1474**	**5843**	**823**	**1499**

Table 3.2 shows the stock and flow of patients from 2012 to 2016. While an increase in new dialysis and transplant patients was observed over the years, the number of deaths had remained relatively stable.

Table 3.2: Stock and Flow (2012 – 2016)

Stock and Flow 2012 – 2016	2012	2013	2014	2015	2016
New dialysis patients	921	976	1041	1090	1166
New transplants (done locally and overseas)	64	88	76	90	93
Dialysis deaths	654	773	764	799	795
Transplant deaths	30	39	32	35	26
Dialysis as at 31st December	5244	5520	5878	6230	6666
Functioning grafts as at 31st December	1422	1451	1454	1474	1500

Incidence of CKD5

In computing the incidence of CKD5, the population of new CKD5 patients for a particular year was extracted based on the date reached CKD5. These included all patients initiating renal replacement therapy or those presenting with serum creatinine ≥ 10 mg/dl or 880 µmol/L. Since 2010, this was subsequently changed to serum creatinine ≥ 500 µmol/L, or eGFR < 15 ml/min (corrected for BSA 1.73m^2), or if patients started renal replacement therapy.

As CKD5 number typically takes 2 years to stabilise due to monitoring of cases for their serum creatinine level for at least 6 months in accordance with the National Kidney Foundation Kidney Disease Outcomes Quality Initiative[6] guidelines, the CKD5 figure for the most recent 2 years is expected to increase and remains tentative. Hence, CKD5 number for 2016 has not been provided in this report.

Incidence of CKD5 on definitive dialysis: 90-day rule

Only patients who survived 90 days after commencement of dialysis (effectively 91 days with respect to the first date of dialysis) were counted in the incidence of CKD5 patients on definitive dialysis. If there was record on the 91st day after commencement of dialysis, the modality was immediately taken for reporting. Otherwise, the modality on the closest date **before** the 91st day was reported. If there was no record between the first date of modality and the 91st day after initiation, the modality reported on the initiation was utilised. The purpose of this was to determine survival characteristics based on a relatively stable CKD5 cohort. Within the first three months, many patients with pre-existing co-morbidities might not survive. This methodology had been adopted from the USRDS.

Prevalence of patients on definitive dialysis/ transplant

To report the prevalent population at the end of a particular year, all surviving cases up till 31 December of that year were included for analysis. They must have survived 90 days after first initiation of the renal replacement therapy. All deceased patients were excluded from analysis.

Death rate: 60-day rule

Deaths were reported according to the last modality that the patient was receiving treatment within the 60 days before death. This rule was also used during survival analysis (see section on survival analysis) for patients who switched modalities.

Survival analysis

The Kaplan-Meier method was used to estimate and compare the unadjusted survival probabilities for patients undergoing definitive haemodialysis, peritoneal dialysis and renal transplantation. Deaths were taken as events in the analysis for

[6] http://www2.kidney.org/professionals/kdoqi/guidelines_ckd/p4_class_g1.htm).

dialysis and transplants. Patients on dialysis were censored if they received transplants.

For analysis of graft survival for kidney transplants, graft loss was defined by return to dialysis or kidney transplant; death with a functioning graft was also defined as an event.

For patients who were alive and not censored for the above reasons, their survival was computed till 28 February 2017, the day when the renal dataset was matched with data from the Ministry of Home Affairs (MHA) death registry.

A proportional hazard Cox regression model was used to examine the effects of multiple covariates on the survival of the patients on definitive dialysis and kidney transplantation. This model assumed that the ratio of hazards for haemodialysis and peritoneal dialysis was constant when comparing the survival between haemodialysis and peritoneal dialysis.

The above-mentioned model took into consideration dialysis modality changes; patients who switched dialysis modality and remained on the switched modality for at least 60 days had their survival experience attributed to the switched modality. Patients who remained on switched modality for less than 60 days had their survival experience attributed to the pre-existing modality.

Bio-clinical indicators

Bio-clinical (e.g. haemoglobin, albumin) values were reported from 2005 onwards when the registry started collecting these data items. Data on serum calcium, phosphate and intact PTH (i-PTH) were added from year 2007 onwards. The most recent reading of the bio-clinical indicators was obtained for each patient in a particular year.

Incidence of kidney transplantation

The incidence of kidney transplant referred to the occurrence of the transplantation in the reporting year. The data had been cleaned with reference to data from the National Organ Transplant Unit, MOH.

Population estimates and age standardisation

In this report, the mid-year population estimates from the Department of Statistics (DOS), Singapore were used to calculate the rates. Segi World Population was used for direct standardisation to calculate age-standardised rates. Both crude and age-standardised rates were expressed in per million population (pmp).

The data presented in this report refers only to Singapore residents i.e. citizens and permanent residents. The data reported here represents the 1999 – 2016

statistics as they stood on 4 May 2017. The figures in this report were rounded to one decimal place.

4 EXECUTIVE SUMMARY

While the crude rate of CKD5 increased from 383.9 pmp in 2010 to 414.8 pmp in 2015, the age-standardised incidence rate (ASR) of CKD5 decreased from 273.8 pmp in 2010 to 256.5 pmp in 2015.[7] An increasing trend was seen in definitive dialysis patients, where its ASR increased from 144.7 pmp in 2010 to 185.3 pmp in 2016.

Haemodialysis (HD) remained the main dialysis modality among incident (78.7% in 2016) and prevalent (87.7% in 2016) CKD5 patients on dialysis. Although majority of the incident and prevalent definitive dialysis patients was Chinese, an increase in the proportion of incident and prevalent definitive dialysis patients was observed among the Malays in the study period.

Diabetic nephropathy (DN) remained the main cause of CKD5 for incident (66.8% of HD, 65.7% of PD in 2016) and prevalent (53.8% of HD, 50.9% of PD in 2016) dialysis patients.

Infections (32.6% in 2016) and cardiac events (32.8% in 2016) remained the two common causes of death among CKD5 patients. After adjusting for the effects of diabetes as primary disease and co-morbidities such as ischaemic heart disease, patients on PD had a 58% higher chance of dying as compared to those on HD.

Patients on dialysis were evaluated based on the 3 aspects which are namely, adequacy of dialysis, management of anaemia, as well as mineral and bone disease. In year 2016, 95.5% of the HD patients and 47.9% of the PD patients were deemed to be adequately dialysed. In terms of anaemia management, the proportion of prevalent HD and PD patients with ESA and Hb level below 10 g/dl was 25.3% and 34.1% respectively in 2016. In the management of mineral and bone disease, patients were assessed if their corrected serum calcium, serum phosphate and serum iPTH were within range. It was observed that in year 2016, about 50% of the patients for both HD and PD had corrected serum calcium level, which was within range. In year 2016, while 56.8% of the HD patients and 57.2% of the PD patients had serum phosphate level which was within range; 24.1% of the HD patients and 28.6% of the PD patients had serum iPTH level which was within range.

The ASR of kidney transplantation was 17.8 pmp in 2016. Overall, glomerulonephritis remained the single main cause for CKD5 among incident (55.9% in 2016) and prevalent (68.9% in 2016) kidney transplant patients.

[7] 2016 figure for CKD5 was not presented as the number typically takes about 2 years to stabilise. The eGFR level of the patients are monitored for at least a 6 month period to assess if it is consistently < 15 ml/min (Corrected for BSA) before being confirmed as a CKD5 diagnosis.

Local living-donor transplants had better 5-year graft survival probability (95.0%) when compared to local deceased-donor (84.3%). Age, diabetes as primary disease, ischaemic heart disease, as well as donor type were significant factors affecting survival of kidney transplant patients.

5 FINDINGS

5.1 Incident CKD5

5.1.1 CKD5 Incidence[8]

Over the years, the numbers of new CKD5 patients notified to SRR increased from 680 in 1999 to 1619 in 2015. Correspondingly, while the crude incidence (CR) of CKD5 had almost doubled, the age-standardised incidence rate (ASR) had increased by only 32% from 1999 to 2015 ($p<0.001$) (See Figure 5.1.1.1 and Table 5.1.1.1). This implies that the increase in the CKD5 cases was mainly driven by the effect of ageing. It can be observed in Figure 5.1.1.3a that as age increased, the incidence of CKD5 increased. Notably, 8.8% of the citizens were aged 65 and above in 2005 and 13.1% in 2016.[9] As diabetes is a major contributor to CKD5, a similar trend was also observed in the National Health Survey 2010. While the crude prevalence of diabetes increased from 8.6% in 1992 to 11.3% in 2010 among all Singapore residents, the age-standardised prevalence of diabetes hovered at about 11.3% in the period of 1992 to 2010.[10]

Notably, the increase in cases was partly due to the change in data extraction criteria in 2007 as described in the Methodology section and inclusion of data from more service providers. The increasing trend of CKD5 was more apparent among patients aged 65 years and above. The figures encompassed all cases diagnosed by physicians to have CKD5, regardless of whether they started on renal replacement therapy.

From 2011 onwards however, the increase in the annual number of new CKD5 patients seemed to slow down. A similar trend was observed in the age-standardised rates.

[8] Refers to unique patients who have reached eGFR<15 ml/min (corrected for BSA) in the particular year. More details in methodology section

[9] http://population.sg/population-in-brief/files/population-in-brief-2016.pdf. Accessed on 5 July 2016

[10] National Health Survey 2010

Figure 5.1.1.1: Number and Rates of Incident CKD5

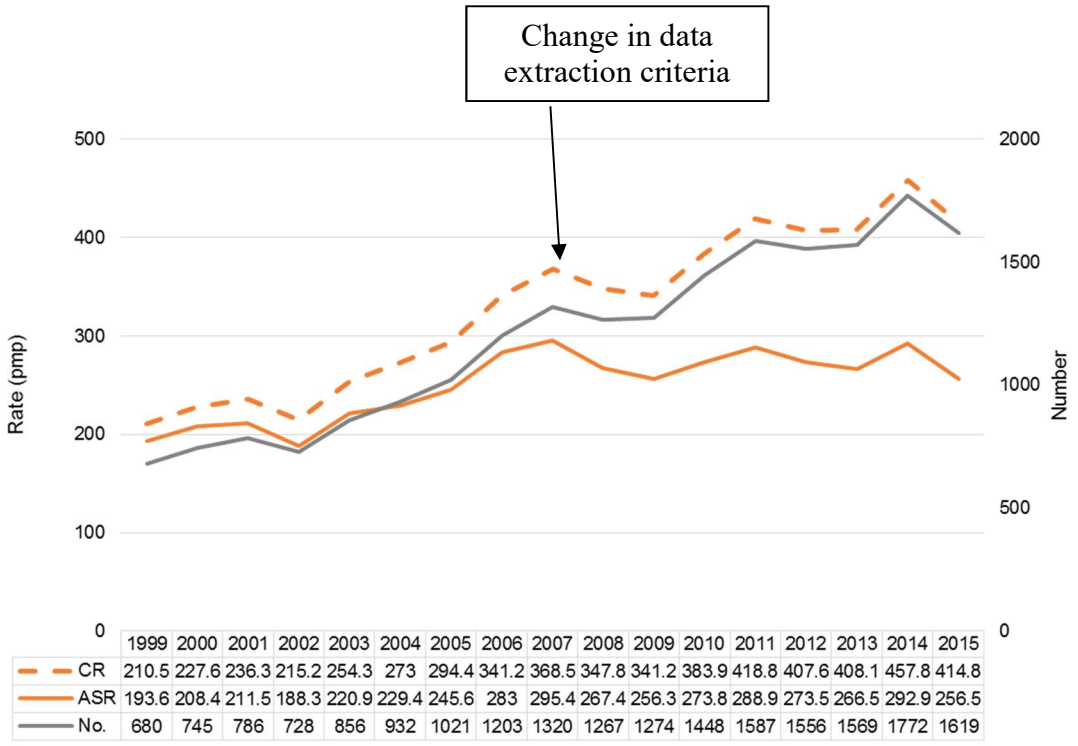


Table 5.1.1.1: Number and Rates of Incident CKD5

Year	No.	CR*	ASR*	ASR 95% CI
1999	680	210.5	193.6	188.9-198.3
2000	745	227.6	208.4	203.6-213.2
2001	786	236.3	211.5	206.8-216.2
2002	728	215.2	188.3	183.9-192.6
2003	856	254.3	220.9	216.1-225.6
2004	932	273.0	229.4	224.6-234.1
2005	1021	294.4	245.6	240.7-250.4
2006	1203	341.2	283.0	277.8-288.2
2007	1320	368.5	295.4	290.2-300.5
2008	1267	347.8	267.4	262.7-272.1
2009	1274	341.2	256.3	251.8-260.8
2010	1448	383.9	273.8	269.2-278.3
2011	1587	418.8	288.9	284.4-293.5
2012	1556	407.6	273.5	269.2-277.9
2013	1569	408.1	266.5	262.3-270.7
2014	1772	457.8	292.9	288.5-297.2
2015	1619	414.8	256.5	252.5-260.5

* *CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR is standardised to World Population. As of the time of analysis, the prelim 2016 number is 1231 (CR: 312.9; ASR: 188.6pmp). As CKD5 typically takes 2 years to stabilise, the figure is expected to increase to 1828 (CR: 469.1) in 2016. A CKD5 case is only registered if the eGFR readings maintained at < 15 ml/min (corrected for BSA) for at least 6 months or for at least 2 consistent readings.*

The incidence of CKD5 was observed to be higher in males as compared to females across the entire study period (Table 5.1.1.2).

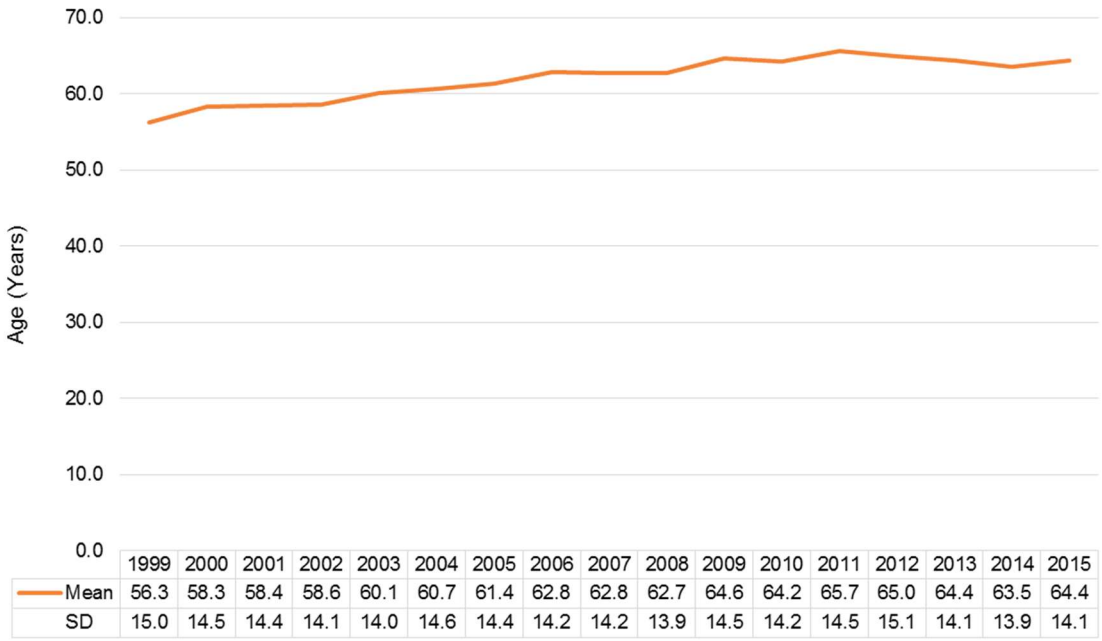
Table 5.1.1.2: Number and Rates of Incident CKD5 by Gender

	Males			Females		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	334	206.8	198.4	346	214.2	190.8
2000	387	236.7	221.6	358	218.5	195.4
2001	418	252.0	234.2	368	220.7	192.5
2002	373	221.4	198.2	355	209.0	180.2
2003	431	257.5	233.4	425	251.0	210.6
2004	477	281.4	248.4	455	264.8	213.1
2005	538	312.6	271.2	483	276.5	220.0
2006	638	364.9	314.8	565	317.9	246.6
2007	669	376.8	313.4	651	360.3	273.7
2008	665	368.9	293.3	602	327.2	239.2
2009	657	356.2	280.2	617	326.6	227.9
2010	773	415.3	315.4	675	353.3	236.2
2011	814	435.7	320.3	773	402.4	259.4
2012	853	453.8	324.4	703	362.8	230.1
2013	817	432.0	296.3	752	385.0	238.5
2014	922	484.6	318.8	850	431.8	263.7
2015	904	471.7	301.8	715	360.0	209.0

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population*

Figure 5.1.1.2 shows that the mean age of new CKD5 patients increased from 56.3 years in 1999 to about 64 years from 2009 onwards. The increase in mean age from 2009 onwards could be an artefact due to the change in data extraction criteria.

Figure 5.1.1.2: Average Age of Incident CKD5 Patients



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mean	56.3	58.3	58.4	58.6	60.1	60.7	61.4	62.8	62.8	62.7	64.6	64.2	65.7	65.0	64.4	63.5	64.4
SD	15.0	14.5	14.4	14.1	14.0	14.6	14.4	14.2	14.2	13.9	14.5	14.2	14.5	15.1	14.1	13.9	14.1

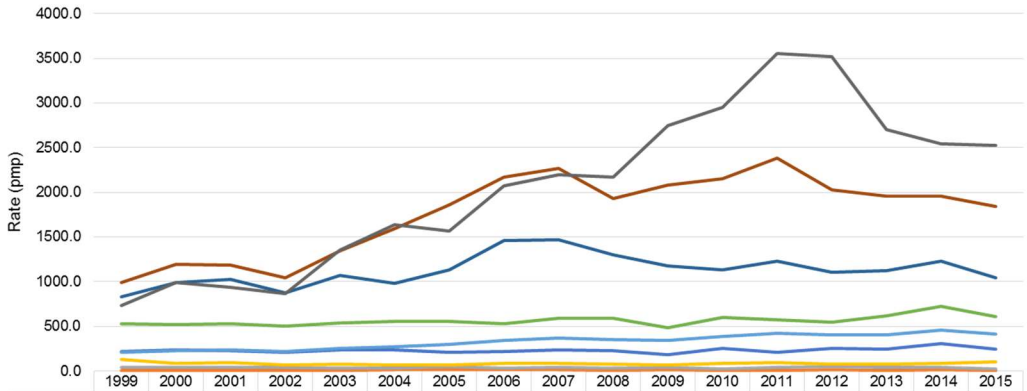
Generally, with the exception of the earlier years from 1999-2001, the incidence of CKD5 was the highest in Malays, followed by the Indians and Chinese (Table 5.1.1.3). In 2015, the ASR for CKD5 among Malays was approximately 3 times as much as the Chinese, while the ASR for CKD5 among the Indians was 1.2 times as much as the Chinese.

Table 5.1.1.3: Number and Rates of Incident CKD5 by Ethnic Group

	Chinese			Malays			Indians		
Year	No.	CR	ASR	No.	CR	ASR	No.	CR	ASR
1999	502	202.2	178.6	132	293.7	339.6	37	146.0	139.5
2000	549	218.4	191.4	142	312.0	379.2	47	182.2	179.0
2001	595	233.1	198.7	145	313.9	378.3	42	159.7	150.8
2002	511	197.3	165.4	155	331.0	377.3	53	194.9	180.7
2003	615	239.1	195.7	167	355.5	407.1	57	211.3	218.0
2004	660	253.9	201.3	187	393.0	412.5	76	273.2	284.5
2005	728	277.2	214.4	195	405.7	445.8	86	295.5	301.9
2006	854	321.5	241.8	242	498.0	560.6	95	313.4	331.0
2007	913	339.8	250.2	294	599.5	606.1	101	322.4	319.5
2008	853	313.4	220.8	306	617.9	606.6	92	284.6	276.6
2009	883	318.7	212.8	292	584.0	590.9	80	233.0	226.4
2010	1015	363.3	234.9	314	623.0	579.9	98	281.7	277.0
2011	1109	394.9	245.9	338	667.5	616.4	115	329.7	294.0
2012	1064	375.8	228.8	353	693.0	612.0	116	330.5	318.7
2013	1062	372.1	221.8	369	719.7	588.9	113	321.5	294.5
2014	1175	408.8	236.5	430	832.3	676.7	131	371.1	308.0
2015	1073	370.0	204.9	404	775.5	615.5	109	307.1	246.0

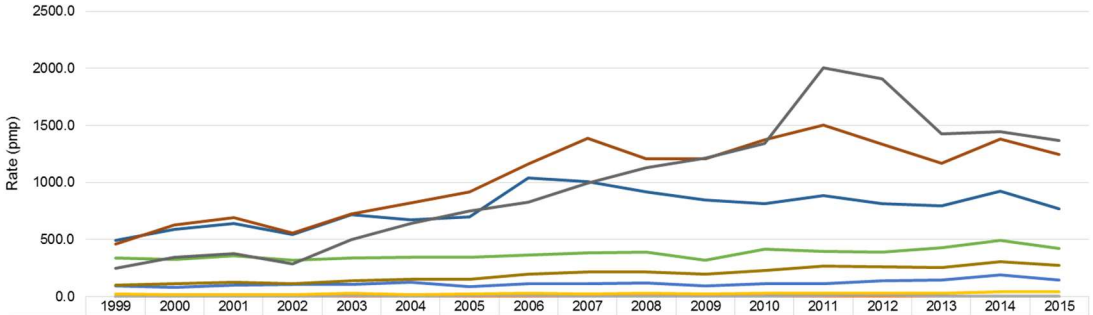
Figures 5.1.1.3a-c shows the age-specific incidence of CKD5 patients, both overall and stratified by whether its etiology was due to DN. Figure 5.1.1.3b shows that the incidence of patients having CKD5 as a result of DN was higher for older age groups.

Figure 5.1.1.3a: Age-Specific Incidence Rates of CKD5 Patients



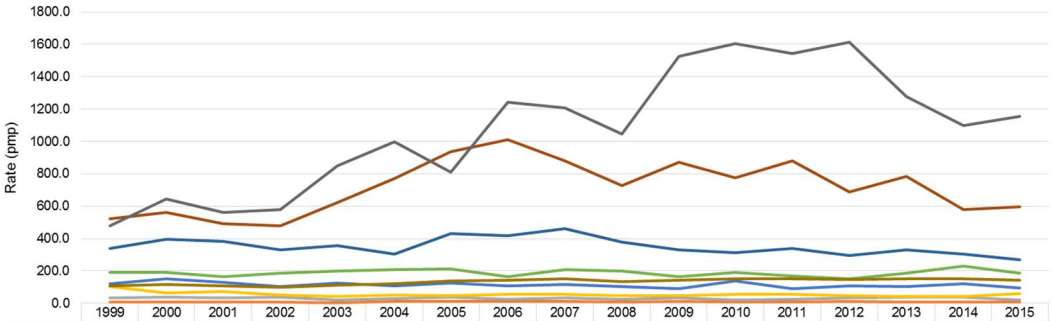
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0-19	7.6	7.5	7.5	5.3	4.3	11.8	9.7	12.9	13.9	6.4	9.7	5.4	7.8	10.2	5.7	9.4	5.9
20-29	39.3	37.5	37.7	39.6	30.0	32.5	45.0	33.9	38.1	28.7	36.8	23.1	36.7	50.1	40.2	43.4	26.2
30-39	130.9	83.2	91.8	65.6	73.6	70.8	69.2	86.2	80.5	78.7	70.0	82.4	89.6	75.5	71.4	84.1	101.4
40-49	215.2	231.3	229.5	212.4	232.4	234.9	213.0	218.6	231.0	225.1	185.7	254.3	207.7	249.3	246.5	309.0	243.5
50-59	529.7	518.4	526.6	505.9	539.5	556.2	557.4	531.6	592.0	592.0	485.7	603.5	568.1	544.5	616.3	720.3	611.3
60-69	832.0	989.9	1023.5	872.4	1072.8	978.1	1130.4	1458.8	1472.1	1297.1	1175.2	1131.3	1229.3	1108.5	1122.0	1227.4	1042.8
70-79	985.2	1192.5	1182.8	1038.6	1347.5	1594.7	1856.5	2173.6	2267.4	1933.0	2080.5	2149.7	2384.7	2023.3	1953.4	1960.6	1844.0
80+	730.5	992.6	939.0	866.7	1353.7	1639.0	1564.4	2067.7	2198.6	2172.5	2742.7	2948.0	3551.9	3518.0	2704.0	2543.1	2525.5
total	210.5	227.6	236.3	215.2	254.3	273.0	294.4	341.2	368.5	347.8	341.2	383.9	418.8	407.6	408.1	457.8	414.8

Figure 5.1.1.3b: Age-Specific Incidence Rates of CKD5 Patients due to Diabetic Nephropathy



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20-29	4.1	0.0	4.2	0.0	8.6	2.2	8.6	8.5	4.2	2.0	1.9	1.9	11.6	15.4	3.8	5.7	5.6
30-39	25.8	18.0	19.7	16.4	30.1	20.2	21.9	28.7	23.5	30.1	21.2	27.5	32.6	27.9	29.9	40.4	42.3
40-49	93.2	78.3	99.5	107.0	106.4	127.1	89.0	111.7	116.3	121.2	94.4	115.3	115.8	141.3	143.1	188.9	146.7
50-59	338.2	328.5	360.6	318.5	340.1	346.1	345.1	365.4	386.0	391.4	321.9	413.2	397.5	393.3	431.0	491.8	424.5
60-69	495.0	593.0	639.1	544.1	718.3	671.8	700.2	1040.1	1010.8	916.9	846.4	817.9	889.2	813.9	793.3	924.4	773.2
70-79	463.1	629.1	690.0	557.9	727.0	822.3	920.4	1162.3	1388.5	1205.4	1208.1	1376.0	1503.9	1337.2	1169.8	1381.7	1245.6
80+	251.9	347.4	375.6	288.9	502.2	643.2	752.5	827.1	992.9	1127.7	1217.3	1343.9	2008.2	1907.2	1425.1	1443.4	1369.7
total	101.2	111.2	127.8	114.7	141.7	150.6	155.2	199.1	217.5	214.7	200.3	232.5	266.0	261.9	255.2	305.9	272.1

Figure 5.1.1.3c: Age-Specific Incidence Rates of CKD5 Patients not due to Diabetic Nephropathy



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0-19	7.6	7.5	7.5	5.3	4.3	11.8	9.7	12.9	13.9	6.4	9.7	5.4	7.8	10.2	5.7	9.4	5.9
20-29	35.2	37.5	33.5	39.6	21.4	30.3	36.4	25.5	33.8	26.6	34.9	21.2	25.1	34.7	36.4	37.8	20.6
30-39	105.0	65.3	72.2	49.2	43.5	50.5	47.3	57.5	57.0	48.6	48.8	55.0	57.0	47.6	41.5	43.7	59.2
40-49	121.9	153.1	129.9	105.4	126.0	107.8	124.0	106.9	114.7	103.9	91.3	139.0	92.0	108.0	103.4	120.1	96.7
50-59	191.4	189.9	166.0	187.4	199.4	210.1	212.3	166.1	206.0	200.5	163.8	190.3	170.6	151.2	185.2	228.5	186.8
60-69	337.0	397.0	384.4	328.3	354.4	306.2	430.2	418.7	461.3	380.2	328.8	313.3	340.1	294.6	328.7	303.0	269.6
70-79	522.2	563.4	492.8	480.7	620.6	772.4	936.0	1011.3	878.9	727.5	872.5	773.6	880.8	686.0	783.6	578.9	598.3
80+	478.6	645.2	563.4	577.8	851.5	995.9	811.9	1240.6	1205.7	1044.8	1525.4	1604.0	1543.7	1610.8	1278.9	1099.7	1155.7
total	109.3	116.4	108.5	100.5	112.6	122.5	139.3	142.1	151.0	133.1	140.9	151.4	152.8	145.6	152.9	151.9	142.7

5.1.2 Incident CKD5 Patients who Ever Started Dialysis

The incidence of CKD5 patients who ever started dialysis was observed to be higher in males as compared to females across the entire study period, except for year 1999. In 2016, the ASR was 253.5 pmp for males and 164.2 pmp for females (Table 5.1.2.1).

Table 5.1.2.1: Number and Rates of Incident Patients who Ever Started Dialysis by Gender

	Males			Females			All		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	301	186.4	176.6	319	197.5	178.2	620	191.9	176.8
2000	351	214.7	199.4	313	191.0	170.0	664	202.8	184.8
2001	382	230.3	212.3	330	197.9	173.9	712	214.1	192.3
2002	367	217.9	193.5	343	201.9	175.1	710	209.9	184.2
2003	350	209.1	186.9	333	196.7	165.5	683	202.9	175.5
2004	393	231.8	202.2	364	211.8	174.3	757	221.8	187.0
2005	435	252.8	218.7	398	227.9	185.1	833	240.2	201.0
2006	463	264.8	227.8	378	212.7	171.2	841	238.5	198.4
2007	520	292.8	239.2	430	238.0	185.0	950	265.2	211.8
2008	471	261.2	207.4	430	233.7	176.7	901	247.4	192.0
2009	479	259.7	207.8	370	195.9	147.3	849	227.4	176.1
2010	519	278.9	208.9	390	204.1	145.5	909	241.0	175.8
2011	624	334.0	245.2	425	221.2	152.8	1049	276.8	197.1
2012	621	330.4	234.9	458	236.3	158.5	1079	282.6	195.4
2013	673	355.8	244.7	519	265.7	172.8	1192	310.1	207.5
2014	665	349.6	231.2	488	247.9	159.0	1153	297.9	193.7
2015	707	368.9	239.5	552	277.9	174.3	1259	322.6	205.4
2016	764	396.0	253.5	541	270.0	164.2	1305	331.8	207.5

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population*

With the exception of 1999-2001, the incidence of CKD5 patients who ever started dialysis was observed to be highest in Malays, followed by Indians and then Chinese. In 2016, the ASR was 528.5 pmp for Malays (about 3 times as much as the Chinese), 245.5 pmp for Indians (about 1.5-fold as much as the Chinese) and 159.7 pmp for Chinese (Table 5.1.2.2).

Table 5.1.2.2: Number and Rates of Incident Patients who Ever Started Dialysis by Ethnic Group

	Chinese			Malays			Indians		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	457	184.1	163.0	117	260.3	294.8	38	150.0	146.4
2000	489	194.5	170.0	125	274.7	319.7	44	170.5	161.5
2001	539	211.2	180.1	133	287.9	343.0	36	136.9	134.5
2002	497	191.9	160.9	155	331.0	366.6	51	187.6	170.1
2003	479	186.2	152.9	141	300.2	324.8	47	174.3	176.3
2004	534	205.4	164.7	154	323.7	335.4	64	230.1	229.6
2005	580	220.8	174.5	160	332.8	352.8	82	281.8	287.9
2006	584	219.8	169.7	188	386.9	429.8	63	207.9	213.5
2007	644	239.7	177.8	220	448.6	453.6	76	242.6	230.6
2008	580	213.1	154.9	234	472.5	452.1	79	244.4	243.2
2009	546	197.1	139.4	235	470.0	465.0	60	174.7	174.5
2010	602	215.5	144.9	229	454.4	419.3	65	186.8	185.2
2011	715	254.6	165.6	239	472.0	420.5	74	212.2	186.8
2012	728	257.1	161.4	260	510.4	442.3	75	213.7	199.2
2013	795	278.6	172.0	292	569.5	474.2	89	253.2	229.9
2014	757	263.4	156.6	292	565.2	459.4	87	246.4	201.8
2015	820	282.8	166.3	318	610.5	477.3	96	270.5	222.2
2016	814	278.5	159.7	357	678.9	528.5	110	308.2	245.5

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population*

A larger proportion of incident CKD5 patients who ever started dialysis were on HD as compared to PD across the entire study period. In 2016, the ASR was 181.6 pmp for HD patients and 25.8 pmp for PD patients (Table 5.1.2.3).

Table 5.1.2.3: Number and Rates of Incident Patients who Ever Started Dialysis by Modality

	HD			PD		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	498	154.2	140.8	122	37.8	36.0
2000	558	170.4	153.5	106	32.4	31.3
2001	614	184.6	165.2	98	29.5	27.1
2002	552	163.2	142.0	158	46.7	42.1
2003	587	174.4	150.3	96	28.5	25.2
2004	670	196.3	164.9	87	25.5	22.1
2005	753	217.2	181.5	80	23.1	19.4
2006	768	217.8	179.7	73	20.7	18.8
2007	874	244.0	193.9	76	21.2	17.9
2008	852	233.9	181.5	49	13.5	10.5
2009	767	205.4	157.9	82	22.0	18.2
2010	834	221.1	160.9	75	19.9	14.9
2011	965	254.7	181.0	84	22.2	16.2
2012	999	261.7	180.6	80	21.0	14.8
2013	1096	285.1	190.3	96	25.0	17.2
2014	1072	276.9	179.8	81	20.9	13.8
2015	1121	287.2	182.5	138	35.4	22.9
2016	1145	291.1	181.6	160	40.7	25.8

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population*

Most of the patients were initiated on dialysis in RHs. In 2016, 93.9% of CKD5 patients were initiated on dialysis in RHs (Table 5.1.2.4a).

Table 5.1.2.4(a): Number and Percentage of Incident Patients who Ever Started Dialysis by Service Providers

	RH		VWO		PTE		All
Year	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**
1999	511	82.4	24	3.9	85	13.7	620
2000	543	81.8	24	3.6	97	14.6	664
2001	595	83.6	15	2.1	102	14.3	712
2002	634	89.3	0	0.0	76	10.7	710
2003	595	87.1	5	0.7	83	12.2	683
2004	670	88.5	12	1.6	75	9.9	757
2005	748	89.8	14	1.7	71	8.5	833
2006	774	92.0	8	1.0	59	7.0	841
2007	859	90.4	2	0.2	89	9.4	950
2008	833	92.5	0	0.0	68	7.5	901
2009	787	92.7	2	0.2	60	7.1	849
2010	852	93.7	0	0.0	57	6.3	909
2011	971	92.6	1	0.1	77	7.3	1049
2012	998	92.5	3	0.3	78	7.2	1079
2013	1116	93.6	2	0.2	74	6.2	1192
2014	1094	94.9	0	0.0	59	5.1	1153
2015	1197	95.1	2	0.2	60	4.8	1259
2016	1225	93.9	0	0.0	80	6.1	1305

Most of the patients were initiated on HD in RHs. In 2016, 93.0% of the patients initiated on HD were initiated in RHs (Table 5.1.2.4b).

Table 5.1.2.4(b): Number and Percentage of Incident Patients who Ever Started HD by Service Providers

	RH		VWO		PTE		All
Year	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**
1999	399	80.1	24	4.8	75	15.1	498
2000	442	79.2	24	4.3	92	16.5	558
2001	507	82.6	15	2.4	92	15.0	614
2002	486	88.0	0	0.0	66	12.0	552
2003	506	86.2	3	0.5	78	13.3	587
2004	586	87.5	10	1.5	74	11.0	670
2005	674	89.5	11	1.5	68	9.0	753
2006	708	92.2	4	0.5	56	7.3	768
2007	786	89.9	2	0.2	86	9.8	874
2008	785	92.1	0	0.0	67	7.9	852
2009	706	92.0	2	0.3	59	7.7	767
2010	778	93.3	0	0.0	56	6.7	834
2011	888	92.0	1	0.1	76	7.9	965
2012	920	92.1	3	0.3	76	7.6	999
2013	1021	93.2	2	0.2	73	6.7	1096
2014	1014	94.6	0	0.0	58	5.4	1072
2015	1059	94.5	2	0.2	60	5.4	1121
2016	1065	93.0	0	0.0	80	7.0	1145

Most of the patients were initiated on PD in RHs. In 2016, 100% of the patients initiated on PD were initiated in the RHs (Table 5.1.2.4c).

Table 5.1.2.4(c): Number and Percentage of Incident Patients who Ever Started PD by Service Providers

	RH		VWO		PTE		All
Year	No.	%	No.	%	No.	%	No.
1999	112	91.8	0	0.0	10	8.2	122
2000	101	95.3	0	0.0	5	4.7	106
2001	88	89.8	0	0.0	10	10.2	98
2002	148	93.7	0	0.0	10	6.3	158
2003	89	92.7	2	2.1	5	5.2	96
2004	84	96.6	2	2.3	1	1.1	87
2005	74	92.5	3	3.8	3	3.8	80
2006	66	90.4	4	5.5	3	4.1	73
2007	73	96.1	0	0.0	3	3.9	76
2008	48	98.0	0	0.0	1	2.0	49
2009	81	98.8	0	0.0	1	1.2	82
2010	74	98.7	0	0.0	1	1.3	75
2011	83	98.8	0	0.0	1	1.2	84
2012	78	97.5	0	0.0	2	2.5	80
2013	95	99.0	0	0.0	1	1.0	96
2014	80	98.8	0	0.0	1	1.2	81
2015	138	100.0	0	0.0	0	0.0	138
2016	160	100.0	0	0.0	0	0.0	160

5.1.3 Incident CKD5 Patients on Definitive Dialysis

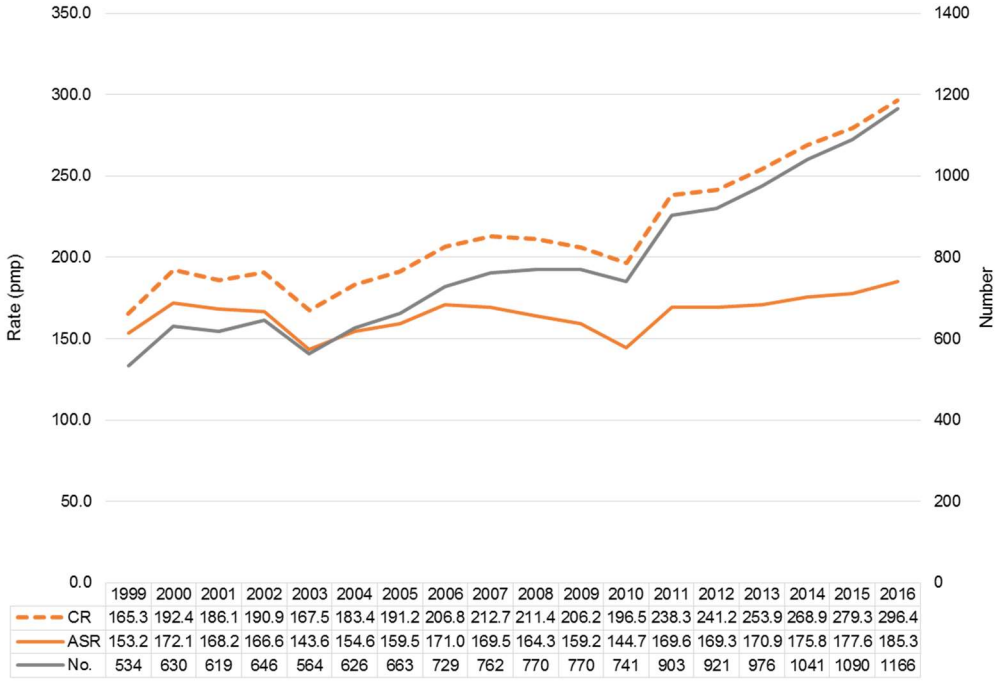
Similar to the pattern in trend among CKD5 patients diagnosed, a similar trend was observed among those on dialysis. The increase in the number of patients on definitive dialysis mirrored the trend in crude incidence rate rather closely over the years. While the number of new cases of CKD5 patients on definitive dialysis increased from 534 in 1999 to 1166 in 2016, the crude incidence rates increased from 165.3 pmp in 1999 to 296.4 pmp in 2016.

Notably, the number and crude incidence rates of CKD5 patients on definitive dialysis dropped in 2003, likely due to SARS epidemic in Singapore as possibly fewer people were diagnosed due to reduced access to hospitals.

The ASR among the definitive dialysis patients remained relatively stable, and ranged between 153.2 pmp in 1999 and 185.3 pmp in 2016. The trend in ASR remained relatively constant in comparison with the increasing trend of CR over

the years, suggesting that the increase in number and crude rate in the recent years was mainly associated with ageing (see Figure 5.1.3.1 and Table 5.1.3.1).

Figure 5.1.3.1: Number and Rates of Incident Definitive Dialysis Patients



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CR	165.3	192.4	186.1	190.9	167.5	183.4	191.2	206.8	212.7	211.4	206.2	196.5	238.3	241.2	253.9	268.9	279.3	296.4
ASR	153.2	172.1	168.2	166.6	143.6	154.6	159.5	171.0	169.5	164.3	159.2	144.7	169.6	169.3	170.9	175.8	177.6	185.3
No.	534	630	619	646	564	626	663	729	762	770	770	741	903	921	976	1041	1090	1166

Table 5.1.3.1: Number and Rates of Incident Definitive Dialysis Patients

Year	No.	CR*	ASR*	ASR 95% C.I.
1999	534	165.3	153.2	149.0-157.4
2000	630	192.4	172.1	167.8-176.5
2001	619	186.1	168.2	163.9-172.4
2002	646	190.9	166.6	162.5-170.7
2003	564	167.5	143.6	139.8-147.4
2004	626	183.4	154.6	150.7-158.5
2005	663	191.2	159.5	155.6-163.4
2006	729	206.8	171.0	167.0-175.0
2007	762	212.7	169.5	165.6-173.3
2008	770	211.4	164.3	160.6-168.0
2009	770	206.2	159.2	155.6-162.8
2010	741	196.5	144.7	141.4-148.1
2011	903	238.3	169.6	166.0-173.1
2012	921	241.2	169.3	165.8-172.9
2013	976	253.9	170.9	167.4-174.3
2014	1041	268.9	175.8	172.3-179.2
2015	1090	279.3	177.6	174.3-181.0
2016	1166	296.4	185.3	181.9-188.8

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

Generally there was a higher proportion of male patients on dialysis than females, except in 1999 (Figure 5.1.3.1). This corresponds to the ASR of males being higher than females, as shown in Table 5.1.3.2.

Figure 5.1.3.2: Percentage of Incident Definitive Dialysis Patients by Gender

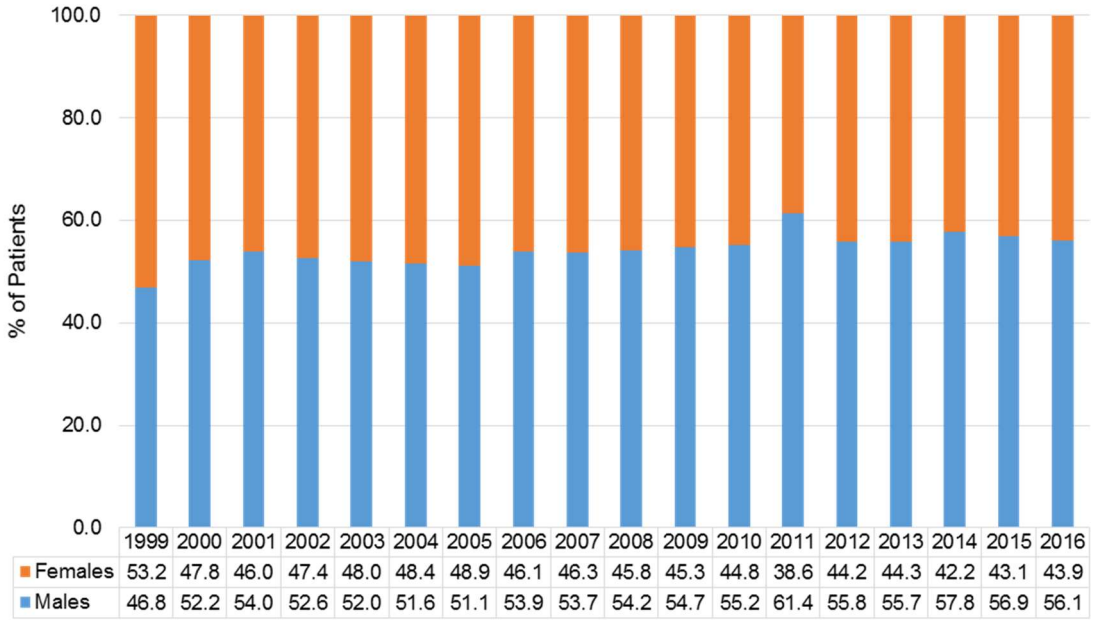


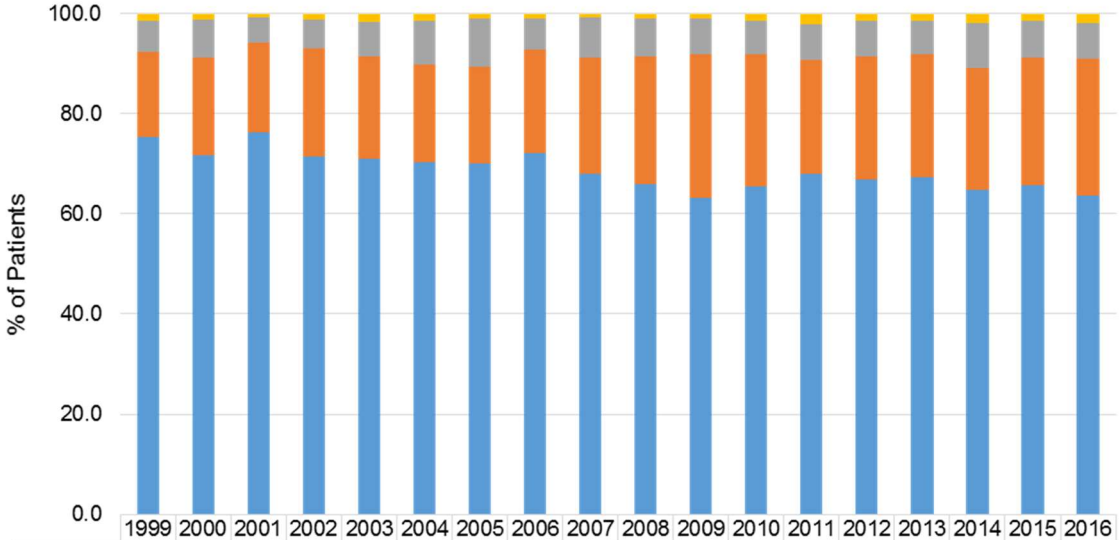
Table 5.1.3.2: Number and Rates of Incident Definitive Dialysis Patients by Gender

	Males			Females		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	250	154.8	147.0	284	175.8	159.1
2000	329	201.2	184.3	301	183.7	160.1
2001	334	201.4	186.4	285	170.9	150.4
2002	340	201.8	177.8	306	180.1	156.1
2003	293	175.1	154.3	271	160.1	133.7
2004	323	190.5	164.4	303	176.3	146.1
2005	339	197.0	167.5	324	185.5	152.2
2006	393	224.8	191.4	336	189.1	152.3
2007	409	230.3	186.6	353	195.4	152.7
2008	417	231.3	184.5	353	191.9	145.0
2009	421	228.2	181.3	349	184.7	137.0
2010	409	219.8	166.1	332	173.8	125.7
2011	554	296.5	217.1	349	181.7	125.6
2012	514	273.4	195.9	407	210.0	144.1
2013	544	287.6	198.2	432	221.2	145.5
2014	602	316.4	209.2	439	223.0	143.8
2015	620	323.5	209.2	470	236.6	148.6
2016	654	338.9	215.1	512	255.5	158.4

* *CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

Although more than 60% of the dialysis patients were Chinese, the proportion of Chinese among the new CKD5 patients on definitive dialysis decreased from 75.5% in 1999 to 63.6% in 2016 (Figure 5.1.3.3). However, ASR for CKD5 on definitive dialysis held steady for the Chinese in this period. The ASR for CKD5 on definitive dialysis has increased steadily among Malays and Indians. The increase in proportion of CKD5 among Malays and Indians corresponded to the increase in proportion of diabetics among these subpopulations (11.3% in 1998 and 16.6% in 2010 for Malays; 15.8% in 1998 and 17.2% in 2010 for Indians [11]). The corresponding rates by ethnic groups are presented in Table 5.1.3.3.

Figure 5.1.3.3: Percentage of Incident Definitive Dialysis Patients by Ethnic Group



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Others	1.5	1.3	0.6	1.1	1.6	1.4	1.1	1.0	0.8	1.0	0.9	1.5	2.1	1.5	1.3	1.8	1.5	1.9
Indians	6.2	7.5	5.2	5.9	6.9	8.6	9.7	6.3	7.9	7.5	7.1	6.6	7.1	7.1	6.7	8.9	7.3	7.1
Malays	16.9	19.5	17.9	21.5	20.4	19.6	19.3	20.6	23.4	25.5	28.7	26.3	22.8	24.6	24.7	24.5	25.4	27.4
Chinese	75.5	71.7	76.3	71.5	71.1	70.3	70.0	72.2	68.0	66.0	63.2	65.6	68.0	66.8	67.3	64.7	65.8	63.6

[11] National Health Survey 1998 and 2010. Epidemiology and Disease Control Division. Ministry of Health, Singapore

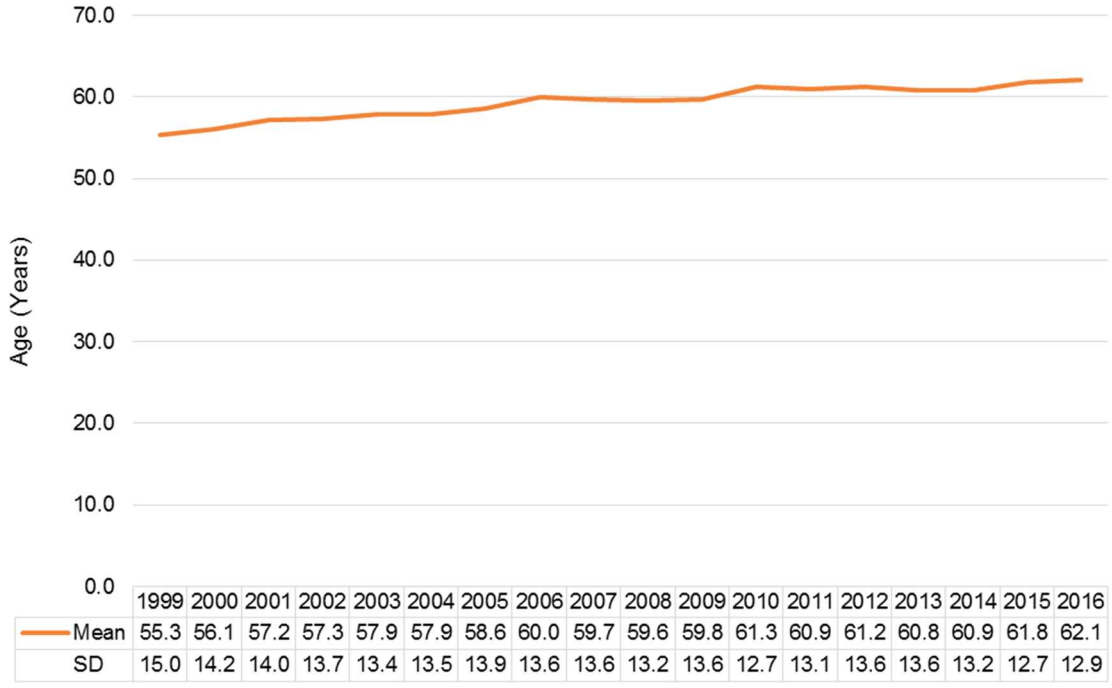
Table 5.1.3.3: Number and Rates of Incident Definitive Dialysis Patients by Ethnic Group

	Chinese			Malays			Indians		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	403	162.3	143.9	90	200.2	232.6	33	130.2	129.6
2000	452	179.8	154.9	123	270.3	299.7	47	182.2	171.5
2001	472	184.9	158.3	111	240.3	286.6	32	121.7	118.8
2002	462	178.4	148.6	139	296.8	328.1	38	139.8	129.7
2003	401	155.9	126.7	115	244.8	265.9	39	144.6	139.2
2004	440	169.2	136.4	123	258.5	263.4	54	194.1	192.0
2005	464	176.7	138.9	128	266.3	273.8	64	219.9	228.1
2006	526	198.0	153.4	150	308.7	332.6	46	151.8	145.9
2007	518	192.8	142.3	178	363.0	372.3	60	191.5	184.8
2008	508	186.6	135.9	196	395.8	375.8	58	179.4	181.4
2009	487	175.8	125.2	221	442.0	424.7	55	160.2	156.2
2010	486	174.0	117.4	195	386.9	362.2	49	140.8	141.6
2011	614	218.6	143.2	206	406.8	356.9	64	183.5	166.0
2012	615	217.2	138.0	227	445.6	395.1	65	185.2	175.7
2013	657	230.2	144.4	241	470.1	382.9	65	184.9	162.1
2014	674	234.5	141.0	255	493.6	396.8	93	263.4	223.6
2015	717	247.2	144.4	277	531.7	420.3	80	225.4	177.6
2016	742	253.8	144.7	319	606.6	468.7	83	232.6	188.5

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

Figure 5.1.3.4 shows that the mean age of new definitive dialysis patients increased from 55.3 years in 1999 to 62.1 years in 2016.

Figure 5.1.3.4: Average Age of Incident Definitive Dialysis Patients



There was an increasing trend for HD as a renal replacement therapy option of choice for incident patients at 90 days after initiation of dialysis from 2002 to 2008. The trend seemed to have stabilised from 2008 to 2014. This implies that there is a greater dependence on provision of facilities (dialysis centres) and manpower (nursing) if this trend is not reversed. However, from 2015 onwards, there seemed to be a decreasing trend of HD (Figure 5.1.3.5). The corresponding rates by modality are presented in Table 5.1.3.4.

Figure 5.1.3.5: Percentage of Incident Definitive Dialysis Patients by Modality

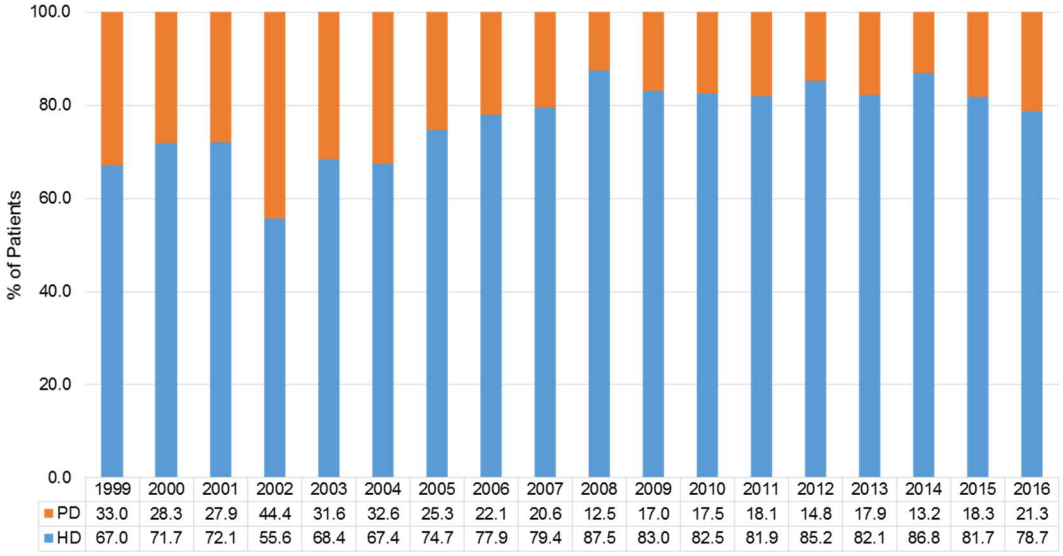
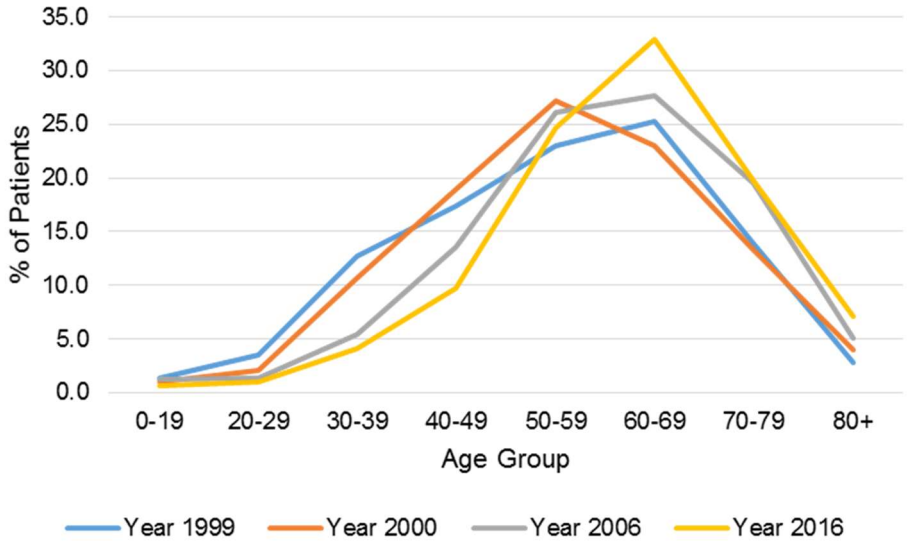


Table 5.1.3.4: Number and Rates of Incident Definitive Dialysis Patients by Modality

	HD			PD		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	358	110.8	99.3	176	54.5	54.0
2000	452	138.1	120.5	178	54.4	51.6
2001	446	134.1	119.6	173	52.0	48.6
2002	359	106.1	92.2	287	84.8	74.4
2003	386	114.7	97.5	178	52.9	46.1
2004	422	123.6	103.2	204	59.8	51.3
2005	495	142.8	117.1	168	48.4	42.4
2006	568	161.1	131.6	161	45.7	39.4
2007	605	168.9	132.7	157	43.8	36.8
2008	674	185.0	143.9	96	26.4	20.4
2009	639	171.1	130.6	131	35.1	28.6
2010	611	162.0	118.6	130	34.5	26.1
2011	740	195.3	138.4	163	43.0	31.1
2012	785	205.6	143.0	136	35.6	26.3
2013	801	208.4	139.5	175	45.5	31.4
2014	904	233.5	152.4	137	35.4	23.4
2015	890	228.0	143.7	200	51.2	33.9
2016	918	233.4	144.3	248	63.0	41.0

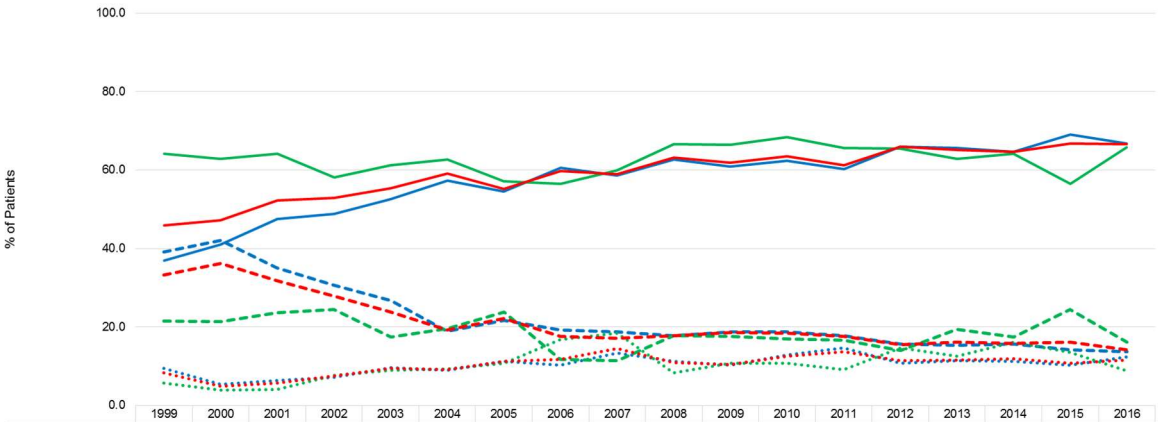
The proportion of dialysis patients in the older age groups has increased in 2016 compared to 1999 (Figure 5.1.3.6), which is consistent with similar changes in Singapore population demographics.

Figure 5.1.3.6: Percentage of Incident Definitive Dialysis Patients by Age Groups



Diabetic nephropathy (DN) was the most common cause of CKD5 on definitive dialysis for HD and PD patients. DN as an etiology of CKD5 accounted for more than 50% of dialysis cases in general (Figure 5.1.3.7). In contrast, it was observed that glomerulonephritis (GN) was the major cause of CKD5 among transplant patients instead of DN.

Figure 5.1.3.7: Percentage of Incident Definitive Dialysis Patients by Modality and Etiology (DN, GN and HYP)



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
[HD] DN	36.9	40.9	47.5	48.7	52.6	57.3	54.5	60.6	58.7	62.8	60.9	62.4	60.3	66.0	65.5	64.7	69.0	66.8
[HD] GN	39.1	42.0	35.0	30.6	26.7	19.0	21.6	19.2	18.7	17.8	18.8	18.8	17.8	15.7	15.4	15.6	14.2	13.6
[HD] HYP	9.5	5.3	6.3	7.2	9.6	9.0	11.3	10.2	13.4	11.3	10.3	12.9	14.6	10.8	11.4	11.2	10.2	12.3
[PD] DN	64.2	62.9	64.2	58.2	61.2	62.7	57.1	56.5	59.9	66.7	66.4	68.5	65.6	65.4	62.9	64.2	56.5	65.7
[PD] GN	21.6	21.3	23.7	24.4	17.4	19.6	23.8	11.8	11.5	17.7	17.6	16.9	16.6	14.0	19.4	17.5	24.5	16.1
[PD] HYP	5.7	3.9	4.0	7.7	9.0	9.3	10.7	16.8	18.5	8.3	10.7	10.8	9.2	14.7	12.6	16.1	13.5	8.9
[HD + PD] DN	45.9	47.1	52.2	52.9	55.3	59.1	55.2	59.7	58.9	63.2	61.8	63.4	61.2	65.9	65.1	64.6	66.7	66.6
[HD + PD] GN	33.3	36.2	31.8	27.9	23.8	19.2	22.2	17.6	17.2	17.8	18.6	18.5	17.6	15.4	16.1	15.9	16.1	14.2
[HD + PD] HYP	8.2	4.9	5.7	7.4	9.4	9.1	11.2	11.7	14.4	10.9	10.4	12.6	13.6	11.4	11.6	11.8	10.8	11.6

Table 5.1.3.5 showed that regardless of whether the patients had DN or not, about 80% of the patients were on HD in the recent years. It was observed that the proportion of PD patients seemed to have increased in the recent years. Among the DN patients, 21.0% of patients were on PD in 2016; and among the non-DN patients, the proportion of patients on PD ranged from 21.8% to 24.0% in 2015-2016. From 2008 to 2014, the proportion of PD patients tended to be between 10 and 20%.

Table 5.1.3.5: Number and Rates of Incident Dialysis Patients by Modality and Etiology

Year	DN				Non-DN			
	HD		PD		HD		PD	
	No.	%	No.	%	No.	%	No.	%
1999	132	53.9	113	46.1	226	78.2	63	21.8
2000	185	62.3	112	37.7	267	80.2	66	19.8
2001	212	65.6	111	34.4	234	79.1	62	20.9
2002	175	51.2	167	48.8	184	60.5	120	39.5
2003	203	65.1	109	34.9	183	72.6	69	27.4
2004	242	65.4	128	34.6	180	70.3	76	29.7
2005	270	73.8	96	26.2	225	75.8	72	24.2
2006	344	79.1	91	20.9	224	76.2	70	23.8
2007	355	79.1	94	20.9	250	79.9	63	20.1
2008	423	86.9	64	13.1	251	88.7	32	11.3
2009	389	81.7	87	18.3	250	85.0	44	15.0
2010	381	81.1	89	18.9	230	84.9	41	15.1
2011	446	80.7	107	19.3	294	84.0	56	16.0
2012	518	85.3	89	14.7	267	85.0	47	15.0
2013	525	82.7	110	17.3	276	80.9	65	19.1
2014	585	86.9	88	13.1	319	86.7	49	13.3
2015	614	84.5	113	15.5	276	76.0	87	24.0
2016	613	79.0	163	21.0	305	78.2	85	21.8

Table 5.1.3.6a showed that there is an increasing trend of incident definitive dialysis patients in the private centres. In 2016, 62.4% of the new definitive dialysis patients were in the private dialysis centres.

Table 5.1.3.6(a): Number and Percentage of Incident Definitive Dialysis Patients by Service Providers

	RH		VWO		PTE		All
Year	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**
1999	195	36.5	210	39.3	129	24.2	534
2000	206	32.7	239	37.9	185	29.4	630
2001	221	35.7	113	18.3	285	46.0	619
2002	303	46.9	19	2.9	324	50.2	646
2003	197	34.9	47	8.3	320	56.7	564
2004	214	34.2	151	24.1	261	41.7	626
2005	161	24.3	225	33.9	277	41.8	663
2006	169	23.2	236	32.4	324	44.4	729
2007	177	23.2	204	26.8	381	50.0	762
2008	111	14.4	274	35.6	385	50.0	770
2009	170	22.1	215	27.9	385	50.0	770
2010	149	20.1	164	22.1	428	57.8	741
2011	202	22.4	140	15.5	561	62.1	903
2012	172	18.7	178	19.3	571	62.0	921
2013	216	22.1	159	16.3	601	61.6	976
2014	200	19.2	107	10.3	734	70.5	1041
2015	259	23.8	57	5.2	774	71.0	1090
2016	295	25.3	143	12.3	728	62.4	1166

The percentage of new HD patients in the private centres increased from 34.1% in 1999 to 86.9% in 2015 before decreasing to 79.3% in 2016. The corresponding percentage in VWOs decreased from 58.7% in 1999 to 6.3% in 2015 before climbing to 15.6% in 2016 (Table 5.1.3.6b).

Table 5.1.3.6(b): Number and Percentage of Incident Definitive HD Patients by Service Providers

	RH		VWO		PTE		All
Year	No.	%	No.	%	No.	%	No.
1999	26	7.3	210	58.7	122	34.1	358
2000	34	7.5	239	52.9	179	39.6	452
2001	52	11.7	113	25.3	281	63.0	446
2002	35	9.7	17	4.7	307	85.5	359
2003	29	7.5	43	11.1	314	81.3	386
2004	23	5.5	141	33.4	258	61.1	422
2005	37	7.5	185	37.4	273	55.2	495
2006	26	4.6	220	38.7	322	56.7	568
2007	22	3.6	204	33.7	379	62.6	605
2008	26	3.9	265	39.3	383	56.8	674
2009	41	6.4	213	33.3	385	60.3	639
2010	23	3.8	163	26.7	425	69.6	611
2011	41	5.5	140	18.9	559	75.5	740
2012	42	5.4	174	22.2	569	72.5	785
2013	45	5.6	157	19.6	599	74.8	801
2014	66	7.3	104	11.5	734	81.2	904
2015	61	6.9	56	6.3	773	86.9	890
2016	47	5.1	143	15.6	728	79.3	918

The majority of new PD patients were observed to be in RHs. In 2016, 100.0% of the new PD patients were in the RHs (Table 5.1.3.6c).

Table 5.1.3.6(c): Number and Percentage of Incident Definitive PD Patients by Service Providers

	RH		VWO		PTE		All
Year	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**
1999	169	96.0	0	0.0	7	4.0	176
2000	172	96.6	0	0.0	6	3.4	178
2001	169	97.7	0	0.0	4	2.3	173
2002	268	93.4	2	0.7	17	5.9	287
2003	168	94.4	4	2.2	6	3.4	178
2004	191	93.6	10	4.9	3	1.5	204
2005	124	73.8	40	23.8	4	2.4	168
2006	143	88.8	16	9.9	2	1.2	161
2007	155	98.7	0	0.0	2	1.3	157
2008	85	88.5	9	9.4	2	2.1	96
2009	129	98.5	2	1.5	0	0.0	131
2010	126	96.9	1	0.8	3	2.3	130
2011	161	98.8	0	0.0	2	1.2	163
2012	130	95.6	4	2.9	2	1.5	136
2013	171	97.7	2	1.1	2	1.1	175
2014	134	97.8	3	2.2	0	0.0	137
2015	198	99.0	1	0.5	1	0.5	200
2016	248	100.0	0	0.0	0	0.0	248

Overall, the percentage of incident PD patients has increased from 18.3% in 2015 to 21.3% in 2016.

Table 5.1.3.6(d): Number and Percentage of Incident Definitive Patients by Modality and Service Providers

Hospital	2015					2016				
	HD		PD		HD+PD	HD		PD		HD+PD
	No.	%	No.	%		No.	%	No.	%	
Singapore General Hospital	284	81.8	63	18.2	347	327	79.8	83	20.2	410
Alexandra Hospital	17	58.6	12	41.4	29	2	100.0	0	0.0	2
Tan Tock Seng Hospital	177	84.7	32	15.3	209	199	85.0	35	15.0	234
Changi General Hospital	91	82.0	20	18.0	111	100	82.6	21	17.4	121
Khoo Teck Puat Hospital	81	77.9	23	22.1	104	87	67.4	42	32.6	129
Ng Teng Fong General Hospital	5	83.3	1	16.7	6	39	72.2	15	27.8	54
National University Hospital	197	80.7	47	19.3	244	127	70.9	52	29.1	179
Private Centres/Clinics	38	95.0	2	5.0	40	37	100.0	0	0.0	37
ALL	**890**	**81.7**	**200**	**18.3**	**1090**	**918**	**78.7**	**248**	**21.3**	**1166**

The trend of HD patients by service providers remained the same, when stratified by the number of co-morbidities. The private centres received the majority of the HD patients since year 2001 (Table 5.1.3.7).

Table 5.1.3.7: Percentage of Incident Definitive HD Patients by Number of Co-morbidity and Service Providers

%	0 Co-morbidity			1 Co-morbidity			>1 Co-morbidity		
Year	RH	VWO	PTE	RH	VWO	PTE	RH	VWO	PTE
1999	23.1	42.3	34.6	35.2	34.3	30.5	23.0	33.6	43.4
2000	23.5	26.5	50.0	38.1	30.5	31.4	28.5	24.6	46.9
2001	13.5	38.5	48.1	36.3	37.2	26.5	18.9	28.5	52.7
2002	31.4	14.3	54.3	35.3	29.4	35.3	20.8	27.7	51.5
2003	10.3	44.8	44.8	27.9	30.2	41.9	19.7	26.8	53.5
2004	8.7	34.8	56.5	22.0	28.4	49.6	14.7	29.1	56.2
2005	13.5	27.0	59.5	18.9	27.6	53.5	18.3	26.4	55.3
2006	11.5	30.8	57.7	18.6	25.9	55.5	18.3	21.4	60.2
2007	9.1	18.2	72.7	16.7	23.0	60.3	15.8	26.6	57.5
2008	11.5	23.1	65.4	14.3	20.4	65.3	13.6	21.7	64.8
2009	17.1	24.4	58.5	16.9	25.8	57.3	13.2	24.7	62.1
2010	17.4	21.7	60.9	14.1	19.0	66.9	12.7	25.9	61.4
2011	9.8	17.1	73.2	12.9	26.4	60.7	15.4	20.6	64.0
2012	16.7	9.5	73.8	12.6	23.6	63.8	11.8	23.0	65.2
2013	13.3	15.6	71.1	7.6	34.4	58.0	14.0	23.5	62.4
2014	12.1	21.2	66.7	11.5	31.7	56.7	11.3	24.4	64.3
2015	4.9	19.7	75.4	12.5	28.6	58.9	9.8	23.9	66.2
2016	14.9	14.9	70.2	8.4	26.6	65.0	11.3	27.3	61.4

5.2 Prevalent Dialysis Population

As at end of 2016, there were a total of 6666 prevalent patients on dialysis. The number of prevalent patients on dialysis has been increasing since year 1999. The age-standardised prevalence rates increased from 689.3 pmp in 1999 to 1046.5 pmp in 2016 (Table 5.2.1).

Table 5.2.1: Number and Rates of Prevalent Definitive Dialysis Patients

Year	No.	CR*	ASR*	ASR 95% C.I.
1999	2458	760.9	689.3	680.6-698.0
2000	2756	841.9	745.7	736.8-754.6
2001	2981	896.2	785.7	776.8-794.7
2002	3195	944.3	811.6	802.6-820.6
2003	3298	979.6	832.8	823.8-841.9
2004	3407	998.1	827.7	818.8-836.6
2005	3564	1027.8	837.4	828.6-846.2
2006	3773	1070.2	863.5	854.7-872.3
2007	3942	1100.4	870.0	861.4-878.7
2008	4173	1145.6	883.8	875.3-892.3
2009	4381	1173.4	890.9	882.5-899.2
2010	4594	1218.0	896.0	887.8-904.2
2011	4895	1291.8	919.2	911.0-927.3
2012	5244	1373.6	948.7	940.6-956.8
2013	5520	1435.9	961.4	953.4-969.3
2014	5878	1518.6	986.3	978.3-994.2
2015	6230	1596.3	1011.6	1003.7-1019.5
2016	6666	1694.6	1046.5	1038.6-1054.4

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

Males outnumbered females among prevalent dialysis population, except in the year 1999 (Figure 5.2.1). The corresponding rates by gender are shown in Table 5.2.2.

Figure 5.2.1: Percentage of Prevalent Definitive Dialysis Patients by Gender

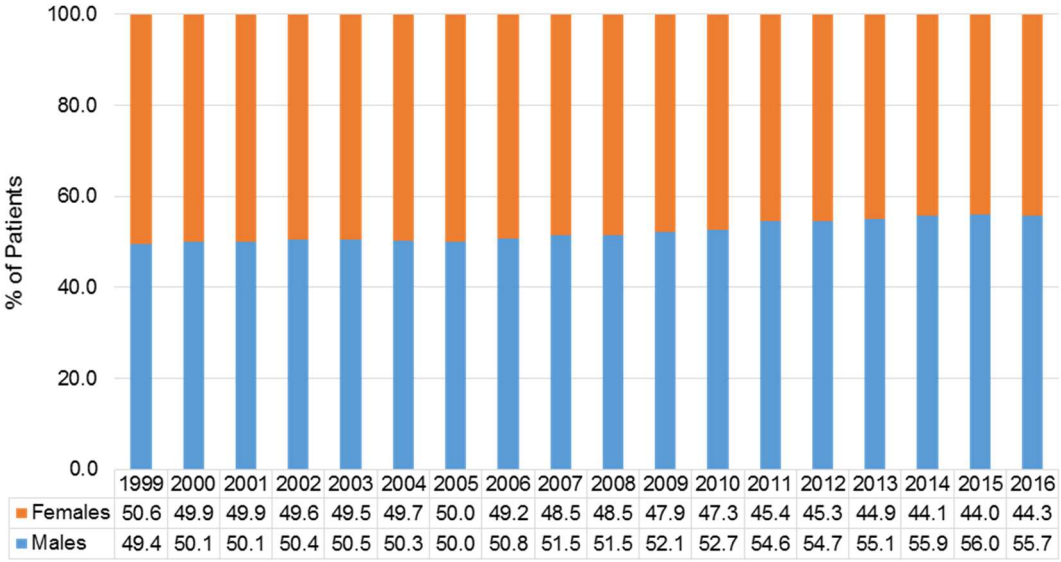


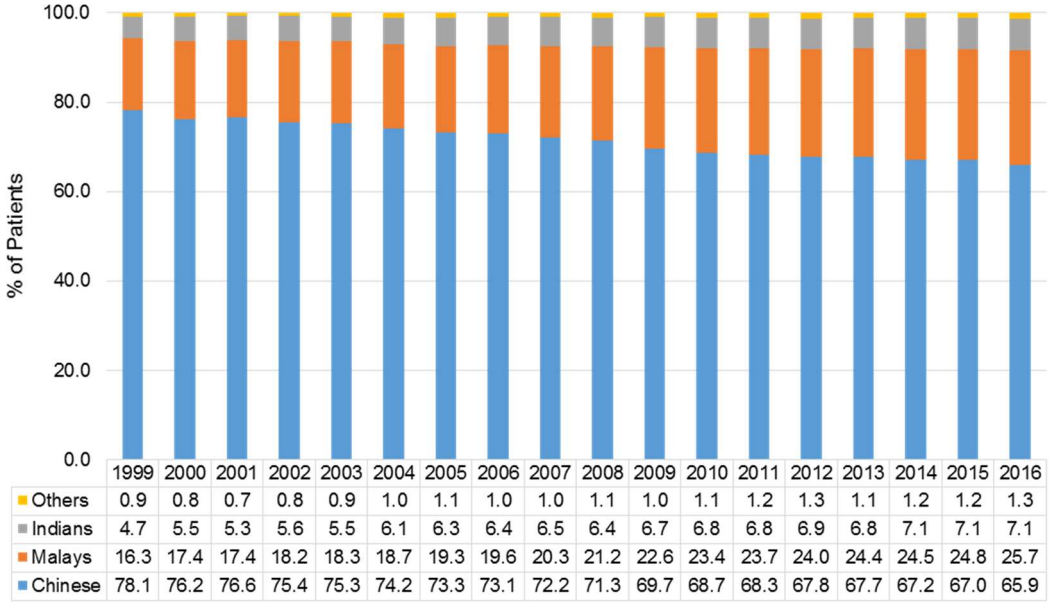
Table 5.2.2: Number and Rates of Prevalent Definitive Dialysis Patients by Gender

	Males			Females		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	1215	752.4	697.2	1243	769.5	682.5
2000	1380	844.0	766.0	1376	839.7	727.0
2001	1493	900.2	808.3	1488	892.2	765.2
2002	1610	955.8	837.0	1585	933.0	787.7
2003	1666	995.5	865.2	1632	963.9	804.3
2004	1714	1011.0	855.1	1693	985.3	802.8
2005	1781	1034.9	857.9	1783	1020.8	819.9
2006	1916	1096.0	901.5	1857	1044.8	829.1
2007	2029	1142.6	923.1	1913	1058.9	821.2
2008	2150	1192.5	943.9	2023	1099.6	829.2
2009	2284	1238.3	964.1	2097	1110.0	821.9
2010	2421	1300.8	982.1	2173	1137.3	816.8
2011	2673	1430.8	1046.0	2222	1156.7	802.9
2012	2867	1525.2	1081.6	2377	1226.6	826.6
2013	3042	1608.4	1104.3	2478	1268.8	830.7
2014	3283	1725.7	1149.3	2595	1318.4	836.2
2015	3490	1820.9	1179.7	2740	1379.6	856.5
2016	3711	1923.3	1215.6	2955	1474.5	891.9

** Crude rates (CR) and age-standardised rates (ASR) are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

Similar to trends in the incident dialysis patients, the percentage of Chinese prevalent dialysis patients decreased from 78.1% in 1999 to 65.9% in 2016, while the percentage of Malay and Indian patients increased from 16.3% to 25.7% and 4.7% to 7.1% respectively over the entire period (Figure 5.2.2). The corresponding rates are shown in Table 5.2.3.

Figure 5.2.2: Percentage of Prevalent Definitive Dialysis Patients by Ethnic Group



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Others	0.9	0.8	0.7	0.8	0.9	1.0	1.1	1.0	1.0	1.1	1.0	1.1	1.2	1.3	1.1	1.2	1.2	1.3
Indians	4.7	5.5	5.3	5.6	5.5	6.1	6.3	6.4	6.5	6.4	6.7	6.8	6.8	6.9	6.8	7.1	7.1	7.1
Malays	16.3	17.4	17.4	18.2	18.3	18.7	19.3	19.6	20.3	21.2	22.6	23.4	23.7	24.0	24.4	24.5	24.8	25.7
Chinese	78.1	76.2	76.6	75.4	75.3	74.2	73.3	73.1	72.2	71.3	69.7	68.7	68.3	67.8	67.7	67.2	67.0	65.9

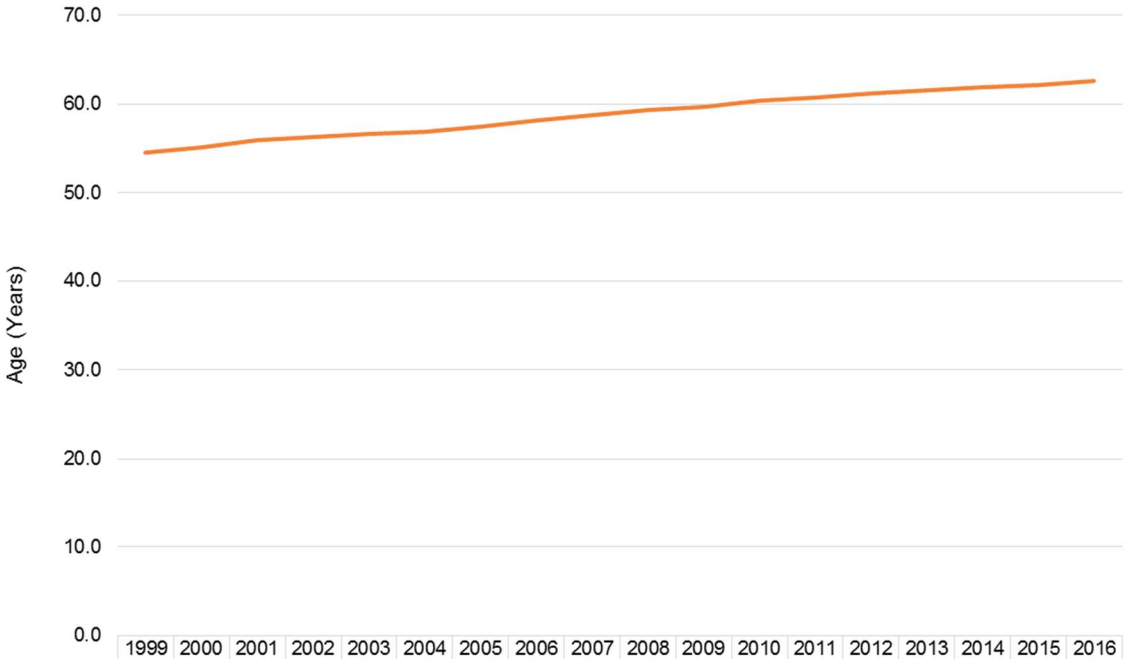
Table 5.2.3: Number and Rates of Prevalent Definitive Dialysis Patients by Ethnic Group

	Chinese			Malays			Indians		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	1920	773.4	676.2	400	889.9	981.9	115	453.8	428.7
2000	2101	835.7	714.0	480	1054.7	1145.6	152	589.1	534.0
2001	2283	894.5	751.6	518	1121.2	1227.3	158	600.8	550.7
2002	2409	930.2	763.4	582	1242.8	1340.0	180	662.0	601.8
2003	2484	965.6	777.6	603	1283.8	1369.6	181	671.1	641.8
2004	2528	972.4	763.1	637	1338.8	1385.0	207	744.1	707.0
2005	2613	994.8	762.7	687	1429.2	1458.3	225	773.2	757.2
2006	2757	1037.9	783.2	738	1518.8	1557.5	241	795.1	775.9
2007	2845	1058.9	779.8	800	1631.3	1630.0	257	820.3	799.7
2008	2975	1093.1	782.6	884	1785.1	1720.7	269	832.0	836.1
2009	3053	1102.0	773.0	990	1980.0	1856.3	295	859.1	859.8
2010	3158	1130.3	763.5	1074	2131.0	1953.4	313	899.7	896.3
2011	3344	1190.7	778.4	1158	2286.7	2018.0	333	954.7	911.1
2012	3557	1256.2	795.9	1259	2471.5	2123.5	360	1025.6	944.6
2013	3738	1309.8	805.4	1345	2623.4	2183.2	376	1069.7	946.7
2014	3950	1374.2	819.5	1441	2789.1	2267.9	417	1181.2	998.0
2015	4175	1439.7	838.6	1542	2960.1	2350.6	440	1239.6	1018.8
2016	4393	1502.8	851.8	1715	3261.2	2527.3	473	1325.4	1059.5

* *CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

Figure 5.2.3 shows that the mean age of prevalent definitive dialysis patients increased from 54.5 years in 1999 to 62.6 years in 2016.

Figure 5.2.3: Average Age of Prevalent Definitive Dialysis Patients



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	54.5	55.1	55.9	56.3	56.6	56.9	57.4	58.2	58.8	59.3	59.7	60.4	60.7	61.2	61.6	61.9	62.2	62.6
SD	13.9	13.8	13.6	13.4	13.1	12.9	13.0	12.9	12.8	12.8	12.8	12.6	12.5	12.5	12.6	12.5	12.4	12.3

The proportion of prevalent dialysis patients on PD has been decreasing from a high of 20.8% in 2004 to 11.6% in 2014, before climbing to 12.3% in 2016 (Figure 5.2.4). The rates of prevalent dialysis patients by modality are shown in Table 5.2.4.

Figure 5.2.4: Percentage of Prevalent Definitive Dialysis Patients by Modality

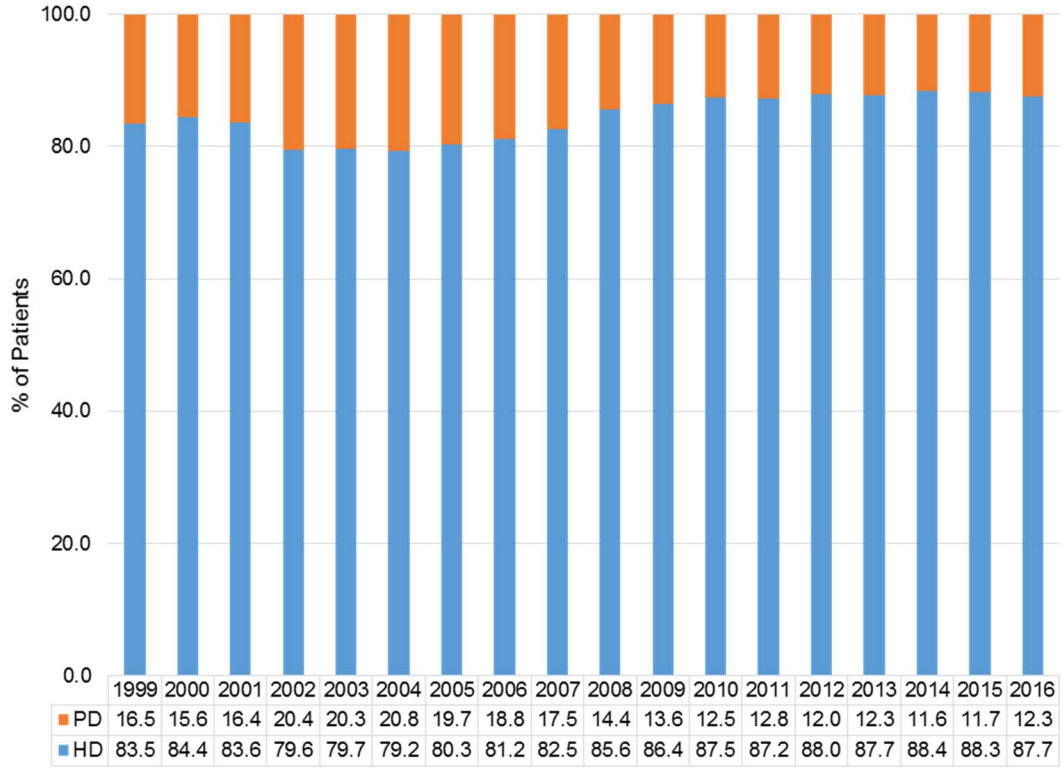


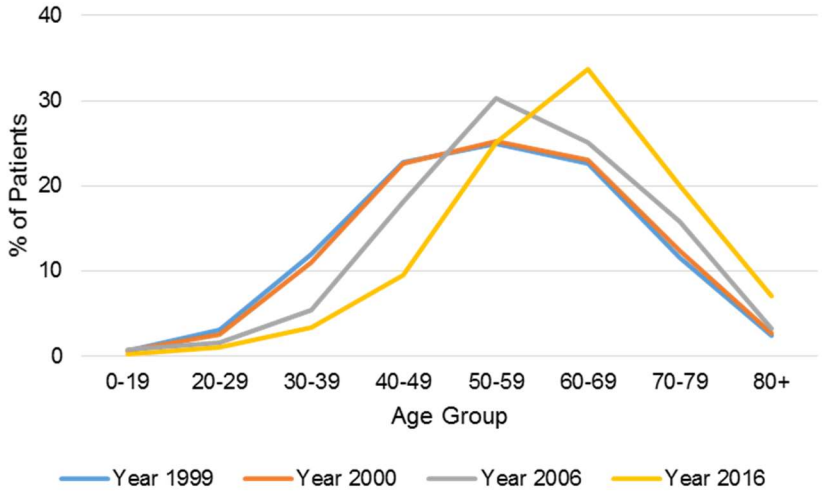
Table 5.2.4: Number and Rates of Prevalent Definitive Dialysis Patients by Modality

	HD			PD		
Year	**No.**	**CR***	**ASR***	**No.**	**CR***	**ASR***
1999	2052	635.3	568.5	406	125.7	120.8
2000	2326	710.5	622.7	430	131.3	123.0
2001	2493	749.5	649.8	488	146.7	135.9
2002	2542	751.3	640.3	653	193.0	171.3
2003	2627	780.3	657.9	671	199.3	174.9
2004	2700	791.0	652.2	707	207.1	175.5
2005	2863	825.6	667.2	701	202.2	170.2
2006	3062	868.5	695.1	711	201.7	168.4
2007	3254	908.4	711.7	688	192.1	158.3
2008	3574	981.2	751.9	599	164.4	131.9
2009	3784	1013.5	762.8	597	159.9	128.0
2010	4018	1065.3	778.0	576	152.7	118.0
2011	4270	1126.9	795.2	625	164.9	124.0
2012	4613	1208.3	828.8	631	165.3	119.9
2013	4841	1259.2	837.8	679	176.6	123.6
2014	5198	1342.9	868.0	680	175.7	118.3
2015	5499	1409.0	886.9	731	187.3	124.7
2016	5843	1485.4	911.7	823	209.2	134.8

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

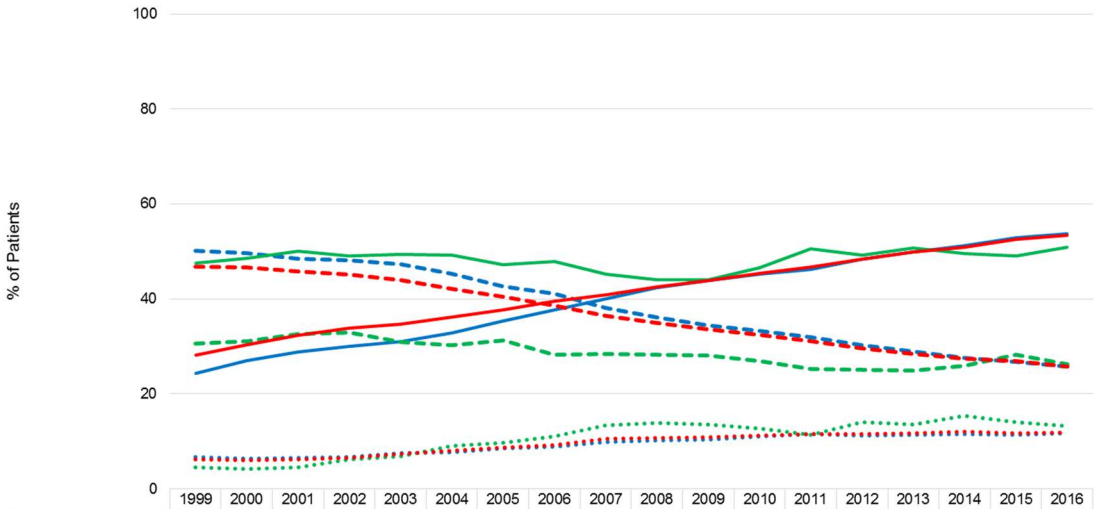
As in incident patients, there was a shift towards an increasing proportion of older prevalent dialysis patients from 1999 to 2016 (Figure 5.2.5).

Figure 5.2.5: Percentage of Prevalent Definitive Dialysis Patients by Age Groups



DN as an etiology of renal failure increased from 24.4% in 1999 to 53.8% in 2016 among prevalent patients on HD as the main cause of CKD5. Among prevalent patients on PD, DN contributed a large proportion of prevalent patients for the period from 1999 to 2016, which ranged from 44.1% to 50.9% (Figure 5.2.6).

Figure 5.2.6: Percentage of Prevalent Definitive Dialysis Patients by Modality and Etiology (DN, GN and HYP)



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
[HD] DN	24.4	27.0	28.9	30.0	30.9	32.8	35.3	37.7	40.0	42.3	43.9	45.2	46.2	48.3	49.8	51.1	52.9	53.8
[HD] GN	50.0	49.6	48.4	48.2	47.3	45.3	42.6	41.1	38.1	36.1	34.4	33.3	31.9	30.2	28.8	27.5	26.7	25.7
[HD] HYP	6.6	6.4	6.5	6.7	7.5	7.7	8.5	8.9	9.8	10.1	10.4	11.1	11.5	11.1	11.4	11.5	11.3	11.6
[PD] DN	47.5	48.6	50.0	49.0	49.3	49.2	47.2	47.8	45.2	44.1	44.1	46.5	50.6	49.3	50.7	49.6	49.1	50.9
[PD] GN	30.5	31.2	32.6	32.9	30.8	30.3	31.2	28.3	28.5	28.2	28.1	26.9	25.3	25.0	24.9	25.9	28.2	26.2
[PD] HYP	4.4	4.2	4.5	6.1	6.9	9.1	9.7	11.0	13.4	13.9	13.6	12.7	11.4	14.1	13.5	15.4	14.1	13.2
[HD+PD] DN	28.2	30.4	32.3	33.9	34.7	36.2	37.7	39.6	40.9	42.5	43.9	45.3	46.8	48.5	49.9	51.0	52.5	53.4
[HD + PD] GN	46.8	46.7	45.8	45.1	44.0	42.2	40.4	38.7	36.4	34.9	33.6	32.5	31.1	29.6	28.4	27.4	26.9	25.7
[HD + PD] HYP	6.3	6.1	6.2	6.6	7.4	8.0	8.7	9.2	10.5	10.7	10.8	11.3	11.5	11.5	11.6	12.0	11.6	11.8

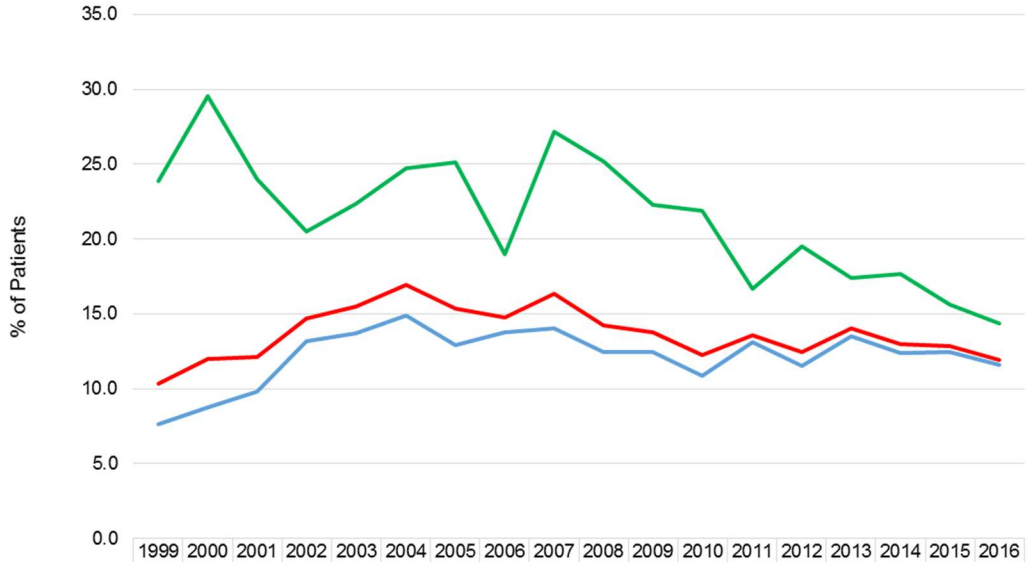
5.3 Mortality in Dialysis Patients

Death rate is defined as the proportion of (all-cause) deaths occurring within the year among all prevalent patients treated by dialysis in the same said year. The denominator in each year comprised of all prevalent patients receiving dialysis in the particular year, and the patient is counted if he is receiving dialysis before death or transplant in the year.

The number of dialysis deaths increased from 254 in 1999 to 795 in 2016. The death rate increased from 10.3% in 1999 to 16.9% in 2004, which then declined to 11.9% in 2016.

The death rates were consistently higher in PD patients than HD patients in the period 1999 to 2016 (Figure 5.3.1). It is likely that the higher death rates seen in PD patients is because of the adverse patient profile of patients who are started on PD. Given that patients with more severe comorbidities may be started on PD as compared to HD, the two patient groups and outcome of mortality are not directly comparable. Despite the increasing age and rising percentage of patients with DN as etiology, the death rate has fallen from 16.9% in 2004 to 11.9% in 2016.

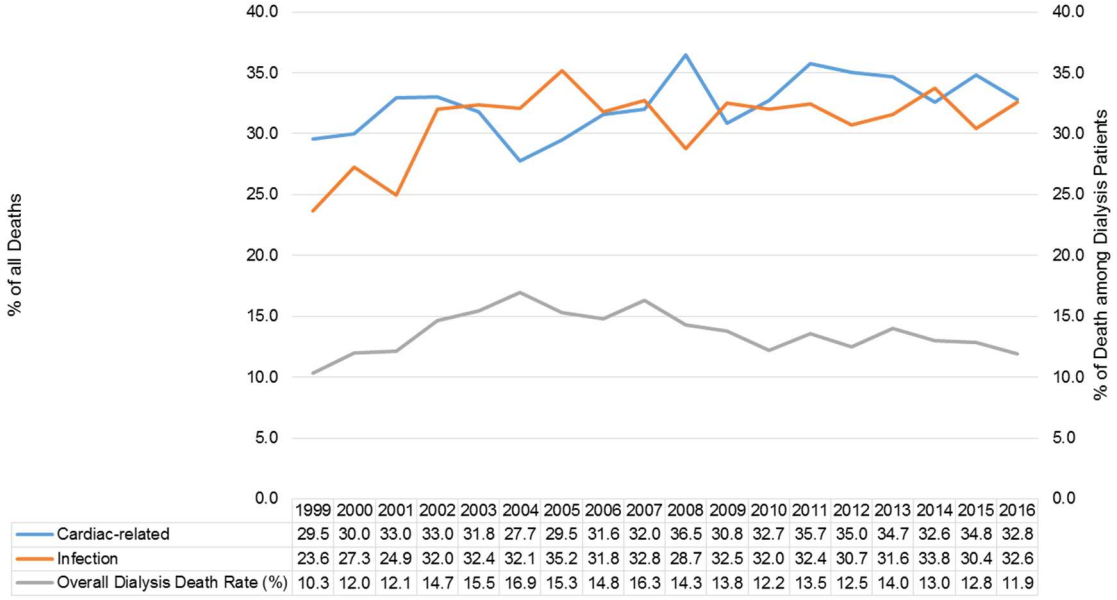
Figure 5.3.1: Percentage of (All-cause) Death by Modality



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
HD	7.7	8.7	9.8	13.2	13.7	14.9	12.9	13.8	14.0	12.4	12.4	10.9	13.1	11.5	13.5	12.4	12.5	11.6
PD	23.9	29.5	24.0	20.5	22.4	24.8	25.1	19.0	27.2	25.2	22.3	21.9	16.6	19.5	17.4	17.6	15.6	14.3
HD+PD	10.3	12.0	12.1	14.7	15.5	16.9	15.3	14.8	16.3	14.3	13.8	12.2	13.5	12.5	14.0	13.0	12.8	11.9

Cardiac events (acute myocardial infarction, acute pulmonary edema and other cardiac causes) accounted for about 27.7% – 36.5% of the deaths while infections accounted for about 23.6% – 35.2% of the deaths during the time period between 1999 and 2016 (Figure 5.3.2).

Figure 5.3.2: Percentage of Dialysis Death by Infection and Cardiac Related Causes



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Cardiac-related	29.5	30.0	33.0	33.0	31.8	27.7	29.5	31.6	32.0	36.5	30.8	32.7	35.7	35.0	34.7	32.6	34.8	32.8
Infection	23.6	27.3	24.9	32.0	32.4	32.1	35.2	31.8	32.8	28.7	32.5	32.0	32.4	30.7	31.6	33.8	30.4	32.6
Overall Dialysis Death Rate (%)	10.3	12.0	12.1	14.7	15.5	16.9	15.3	14.8	16.3	14.3	13.8	12.2	13.5	12.5	14.0	13.0	12.8	11.9

5.4 Survival of Patients on Definitive Dialysis

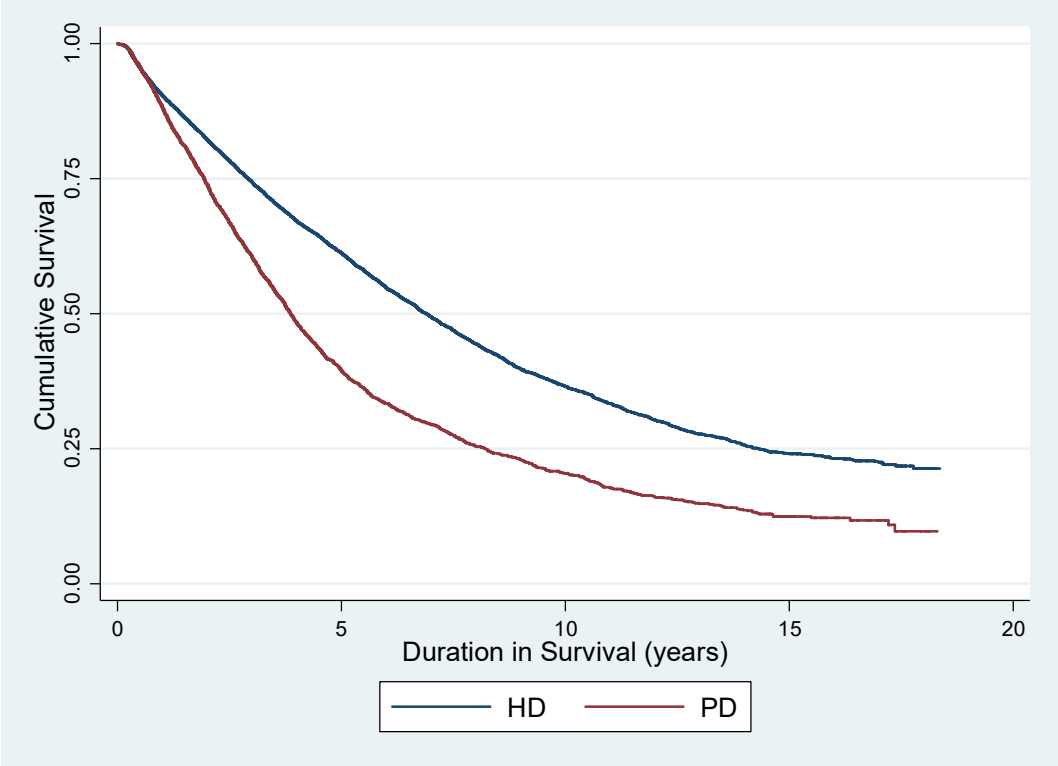
The unadjusted probabilities for surviving 1 year and 5 years for patients on definitive HD were 90.4% and 61.3% respectively, while those for patients on definitive PD were 88.2% and 39.4% respectively (Table 5.4.1, Figure 5.4.1). There was a significant difference in survival probabilities between the dialysis modalities (p<0.001). The median survival for patients on definitive HD was 6.9 years while that for patients on definitive PD was 3.9 years

Table 5.4.1: Survival by Modality

1999-2016	PD	HD
1 year survival (%)	88.2	90.4
5 year survival (%)	39.4	61.3
10 year survival (%)	20.4	36.5
Median survival (years)[12]	3.9	6.9

[12] Median survival is the duration from the date of definitive dialysis (in this instance), that 50% of the patients on dialysis are still alive.

Figure 5.4.1: Survival by Modality

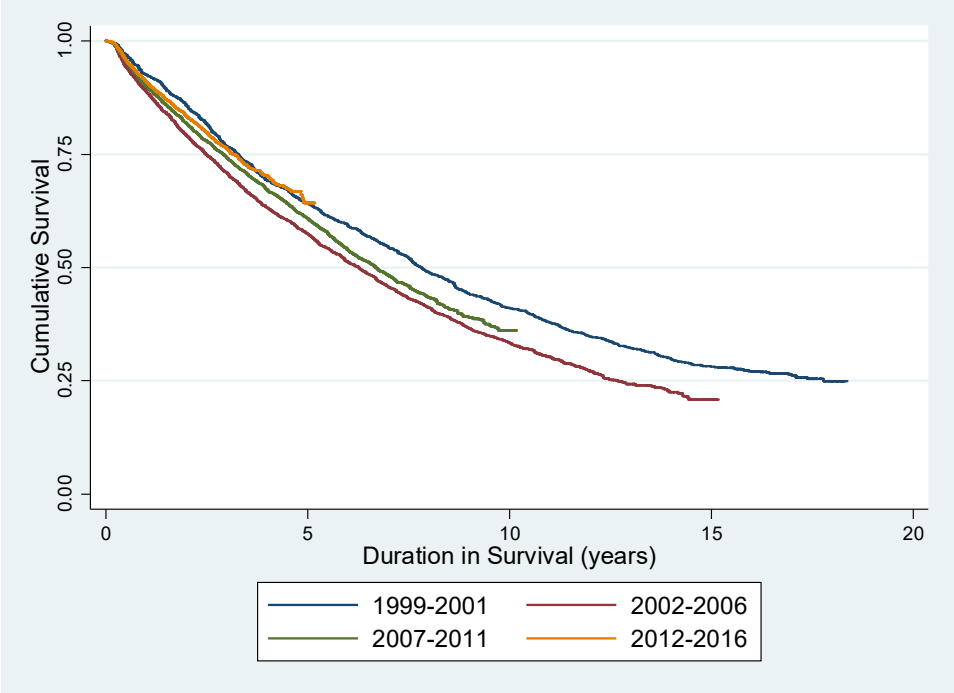


While the 5-year survival for HD patients ranged from 57.5% to 64.3% in the entire study period, the 5-year survival for PD patients increased from 30.3% in 1999-2001 to 54.4% in 2012-2016. (Figure 5.4.2)

Figure 5.4.2: Survival by Period of Definitive Dialysis and Modality

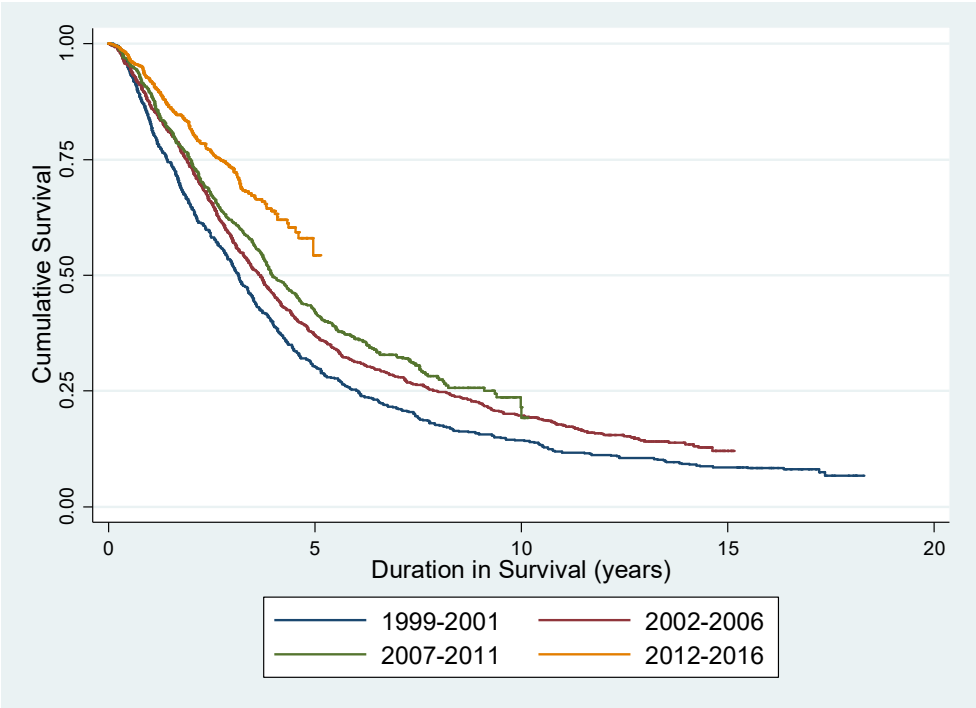
(a) HD

1999-2016	1999-2001	2002-2006	2007-2011	2012-2016
1 year survival (%)	92.6	88.8	90.0	90.9
5 year survival (%)	64.3	57.5	60.8	64.3
10 year survival (%)	41.0	33.4	36.2	-
Median survival (years)	7.8	6.3	6.7	Not reached



(b) PD

1999-2016	1999-2000	2001-2005	2006-2010	2011-2016
1 year survival (%)	83.3	87.0	89.5	92.1
5 year survival (%)	30.3	37.1	42.1	54.4
10 year survival (%)	14.3	19.7	21.5	-
Median survival (years)	3.1	3.7	4.0	Not reached



The probabilities for surviving 1 and 5 years were not significantly different between females compared to males for PD (p = 0.89) and HD (p = 0.94) (Table 5.4.2).

Table 5.4.2: Survival by Gender and Modality

1999-2016	Males		Females	
	PD	HD	PD	HD
1 year survival (%)	88.2	90.3	88.2	90.5
5 year survival (%)	39.9	60.9	39.0	61.8
10 year survival (%)	19.5	37.0	21.2	36.0
Median survival (years)	3.9	6.9	3.8	6.9

Patients aged below 60 years had significantly better survival than patients aged 60 and above for both PD and HD (p<0.001) (Table 5.4.3).

Table 5.4.3: Survival by Age Groups and Modality

1999-2016	Age < 60		Age ≥ 60	
	PD	HD	PD	HD
1 year survival (%)	92.1	93.4	85.0	87.4
5 year survival (%)	56.6	72.5	25.3	49.4
10 year survival (%)	36.5	51.7	6.5	18.7
Median survival (years)	6.0	10.6	3.0	4.9

Among patients aged less than 60 years old, non-diabetics had better survival than the diabetics in both PD and HD (p<0.001). The same finding was observed among patients aged at least 60 years old. Non-diabetics of age<60 years old experienced the best survival (Table 5.4.4).

Table 5.4.4: Survival by Age Groups and Diabetes Status

1999-2016	Diabetics		Non-diabetics	
	Age < 60	Age ≥ 60	Age < 60	Age ≥ 60
1 year survival (%)	90.7	86.3	97.0	88.9
5 year survival (%)	56.6	39.0	88.2	54.6
10 year survival (%)	28.1	11.3	75.9	25.2
Median survival (years)	5.9	3.8	Not reached[13]	5.7

Similarly non-diabetic patients had better survival as compared to diabetics. (Table 5.4.5, Figure 5.4.3). Survival was statistically different among the groups of

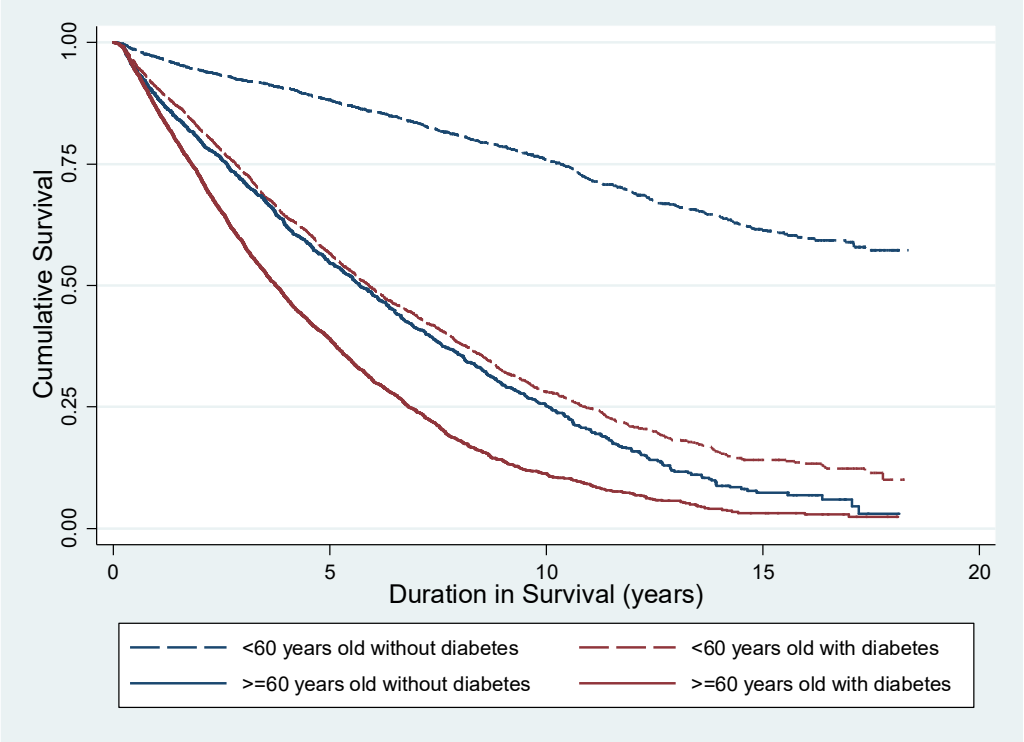
[13] Where median survival is "not reached", it indicates that at the end of the study termination, more than 50% of the patients are still alive.

patients stratified by diabetic status and modality (p<0.001), even after excluding those who were aged less than 60 years and were non-diabetic.

Table 5.4.5: Survival by Presence of Diabetes (DM) and Modality

1999-2016	DM		Non-DM		DM	Non-DM
	PD	HD	PD	HD	PD + HD	PD + HD
1 year survival (%)	85.8	89.0	93.6	93.5	88.3	93.5
5 year survival (%)	27.1	53.3	66.3	76.2	47.0	74.1
10 year survival (%)	7.9	22.9	46.0	58.4	19.2	55.8
Median survival (years)	3.1	5.4	8.8	12.4	4.6	11.5

Figure 5.4.3: Survival by Age and Presence of Diabetes



Tables 5.4.6 to 5.4.10 show that survival for HD patients was better than PD patients, regardless of the presence of IHD, CVD, PVD, malignancy or whether patients present with comorbidity. The difference in survival was more pronounced for a longer term survival.

Table 5.4.6: Survival by Presence of Ischaemic Heart Disease (IHD) and Modality

1999-2016	IHD		Non-IHD		IHD	Non-IHD
	PD	HD	PD	HD	PD + HD	PD + HD
1 year survival (%)	85.2	87.5	91.4	93.0	87.0	92.7
5 year survival (%)	26.5	49.6	53.3	71.1	43.7	67.5
10 year survival (%)	8.6	20.7	33.2	48.2	17.4	45.1
Median survival (years)	3.0	4.9	5.4	9.5	4.2	8.6

Table 5.4.7: Survival by Presence of Cerebrovascular Disease (CVD) and Modality

1999-2016	CVD		Non-CVD		CVD	Non-CVD
	PD	HD	PD	HD	PD + HD	PD + HD
1 year survival (%)	83.5	86.2	90.1	91.7	85.5	91.4
5 year survival (%)	24.8	47.0	45.3	65.4	40.8	61.1
10 year survival (%)	9.2	19.1	24.8	40.7	16.3	37.3
Median survival (years)	2.8	4.6	4.4	7.7	3.9	6.9

Table 5.4.8: Survival by Presence of Peripheral Vascular Disease (PVD) and Modality

1999-2016	PVD		Non-PVD		PVD	Non-PVD
	PD	HD	PD	HD	PD + HD	PD + HD
1 year survival (%)	81.0	83.5	89.6	91.8	83.0	91.3
5 year survival (%)	19.0	43.4	43.5	64.9	38.2	60.1
10 year survival (%)	1.9	15.5	23.4	40.3	12.6	36.4
Median survival (years)	2.5	4.0	4.2	7.7	3.6	6.7

Table 5.4.9: Survival by Presence of Malignancy and Modality

1999-2016	Malignancy		Non-Malignancy		Malignancy	Non-Malignancy
	PD	HD	PD	HD	PD + HD	PD + HD
1 year survival (%)	87.9	82.8	90.5	91.7	83.5	91.4
5 year survival (%)	33.2	44.4	43.9	64.3	43.0	59.8
10 year survival (%)	14.4	21.6	23.0	38.7	20.6	35.1
Median survival (years)	3.3	4.2	4.3	7.4	4.0	6.6

Table 5.4.10: Survival by Presence of Comorbidity and Modality

1999-2016	With Co-morbidity		No Co-morbidity		With Co-morbidity	No Co-morbidity
	PD	HD	PD	HD	PD + HD	PD + HD
1 year survival (%)	86.5	89.0	95.9	96.3	88.4	96.2
5 year survival (%)	31.2	55.2	77.1	85.1	49.6	83.5
10 year survival (%)	11.0	26.5	63.2	70.6	22.7	69.1
Median survival (years)	3.3	5.7	14.0	Not reached	4.9	17.1

Generally, patients without any co-morbidity and less than 60 years of age had better survival as compared to the rest of the patients (Table 5.4.11). There was no statistically significant difference in survival for the group of patients without any co-morbidity and less than 60 years old ($p = 0.11$). However, survival was significantly different for the remaining patients ($p<0.001$).

Table 5.4.11: Survival by Co-morbidity, Age and Modality

1999-2016	No Co-morbidity and <60 years old		Remaining Patients	
	PD	HD	PD	HD
1 year survival (%)	98.4	98.0	86.8	89.2
5 year survival (%)	90.6	91.8	32.3	56.1
10 year survival (%)	80.7	81.6	11.7	27.6
Median survival (years)	Not reached	Not reached	3.4	5.8

Co-morbidities include diabetes mellitus, ischemic heart disease, cerebrovascular disease, peripheral vascular disease, malignancy and smoking.

The Cox regression model (multivariate analysis) showed that several factors affected the survival of patients on dialysis (Table 5.4.12). Age, mode of dialysis, diabetes as primary disease, ischaemic heart disease, cerebrovascular disease, peripheral vascular disease and malignancy were significant risk factors in the model.

Table 5.4.12: Factors Associated with Death in Patients on Definitive Dialysis

Variables	Multivariable		
	HR	95% CI	P-value
Gender:			
-Male	Reference	-	
-Female	0.99	0.94-1.04	0.68
Ethnicity:			0.52
-Chinese	Reference	-	
-Malay	1.02	0.96-1.09	0.44
-Indian	0.97	0.88-1.06	0.48
Age groups:			
<60	Reference	-	
≥60	2.07	1.97-2.19	<0.001
Modality:			
-HD	Reference	-	
-PD	1.58	1.49-1.67	<0.001
Diabetes as primary disease:			
-Absent	Reference	-	
-Present	1.85	1.74-1.96	<0.001
Ischaemic Heart Disease:			
-Absent	Reference	-	
-Present	1.49	1.41-1.57	<0.001
Cerebrovascular Disease:			
-Absent	Reference	-	
-Present	1.37	1.30-1.45	<0.001
Peripheral Vascular Disease:			
-Absent	Reference	-	
-Present	1.52	1.42-1.62	<0.001
Malignancy:			
-Absent	Reference	-	
-Present	1.52	1.39-1.66	<0.001

n= 13,355

5.5 Management of Dialysis Patients

Patients on haemodialysis and peritoneal dialysis were evaluated based on 3 aspects, namely adequacy of dialysis, management of anaemia, as well as presence or absence of mineral and bone disease. The proportions of dialysis patients having relevant readings of various clinical indicators for the evaluation are presented in Tables 5.5.1 and 5.5.2. Results based on year 2016 are presented in the tables. There was not much variation in the results over the years.

While most of the HD were carried out in VWOs (62.1%), 1.7% of the HD patients were in RHs. 100.0% of all patients in VWOs had thrice weekly dialysis. Compared to VWO and private HD patients, a lower proportion of HD patients in RHs had dialysis adequacy measurements (83.0%). The proportion of HD patients with haemoglobin level of at least 10 g/dL was lowest at 48.0% in the RHs, as compared to 81.3% in the VWOs. The percentage of HD patients with last iPTH between 16.3 and 33.0 pmol/L was 22.4% in RHs and 25.4% in the PTEs. The percentage of HD patients with last serum phosphate between 1.13 and 1.78 mmol/L was 46.0% in the RHs and 61.2% in the VWOs.

Table 5.5.1: Clinical Characteristics of HD Patients in 2016

Locations of Dialysis Centres	RHs No. (%)	VWOs No. (%)	PTE No. (%)	All No. (%)
(1) Site of HD				
Number of Patients on dialysis	100 (1.7)	3629 (62.1)	2114 (36.2)	5843 (100)
(2) Adequacy of Dialysis				
Patients with thrice weekly dialysis	99 (99.0)	3629 (100.0)	2034 (96.2)	5762 (98.6)
Patients with measurements of adequacy of dialysis*	83 (83.0)	3611 (99.5)	1955 (92.5)	5649 (96.7)
(3) Management of Anaemia				
Patients with haemoglobin measurements	100 (100.0)	3629 (100.0)	2106 (99.6)	5835 (99.9)
% of patients with last haemoglobin readings at least 10 (g/dl)	48.0	81.3	69.3	76.4
(3a) Assessments of Iron Stores				
Patients with measurements of iron stores†	100 (100.0)	3616 (99.6)	1974 (93.4)	5690 (97.4)
(4) Management of Mineral and Bone Disease				
(4a) Hormone				
Patients with serum iPTH measurements	98 (98.0)	3623 (99.8)	1983 (93.8)	5704 (97.6)
% of patients with last iPTH between 16.3 and 33.0 pmol/L	22.4	23.4	25.4	24.1
(4b) Calcium				
Patients with corrected serum calcium measurements	100 (100.0)	3629 (100.0)	2091 (98.9)	5820 (99.6)
(4c) Serum Phosphate				
Patients with serum phosphate measurements	100 (100.0)	3629 (100.0)	2104 (99.5)	5833 (99.8)
% of patients with last serum phosphate between 1.13 and 1.78 mmol/L	46.0	61.2	49.7	56.8

** Indicators of adequacy of dialysis are determined by URR or fractional clearance of urea (Kt/V) measurements.*
† Indicators of iron stores are determined by serum ferritin and transferrin saturation measurements.
^ Note that the latest available value for the year was used for all analyses.

Majority of the PD were carried out in RHs in year 2016. The proportion of PD patients with haemoglobin level of at least 10 g/dL was lowest at 68.2% in the RHs, as compared to 70.8% in the VWOs. The percentage of PD patients with last iPTH between 16.3 and 33.0 pmol/L was 20.8% in VWOs and 29.0% in the RHs. The percentage of PD patients with last serum phosphate between 1.13 and 1.78 mmol/L was 56.0% in the VWOs and 57.4% in the RHs.

Table 5.5.2: Clinical Characteristics of PD Patients in 2016

	RHs No. (%)	VWOs No. (%)	PTEs No. (%)	All No. (%)
(1) Site of PD				
Number of Patients on PD	796 (96.7)	25 (3.0)	2 (0.2)	823 (100)
(2) Adequacy of Dialysis				
Patients with measurements of adequacy of dialysis*	579 (72.7)	22 (88.0)	0 (0.0)	601 (73.0)
(3) Management of Anaemia				
Patients with haemoglobin measurements	796 (100.0)	24 (96.0)	2 (100.0)	822 (99.9)
% of patients with last haemoglobin readings at least 10 g/dl	68.2	70.8	50.0	68.2
(3a) Assessments of Iron Stores				
Patients with measurements of iron stores†	755 (94.8)	21 (84.0)	1 (50.0)	777 (94.4)
(4) Management of Mineral and Bone Disease				
(4a) Hormone				
Patients with serum iPTH measurements	770 (96.7)	24 (96.0)	2 (100.0)	796 (96.7)
% of patients with last iPTH between 16.3 and 33.0 pmol/L	29.0	20.8	0.0	28.6
(4b) Calcium				
Patients with corrected serum calcium measurements	795 (99.9)	25 (100.0)	2 (100.0)	822 (99.9)
(3c) Serum Phosphate				
Patients with serum phosphate measurements	795 (99.9)	25 (100.0)	2 (100.0)	822 (99.9)
% of patients with last serum phosphate between 1.13 and 1.78 mmol/L	57.4	56.0	0.0	57.2

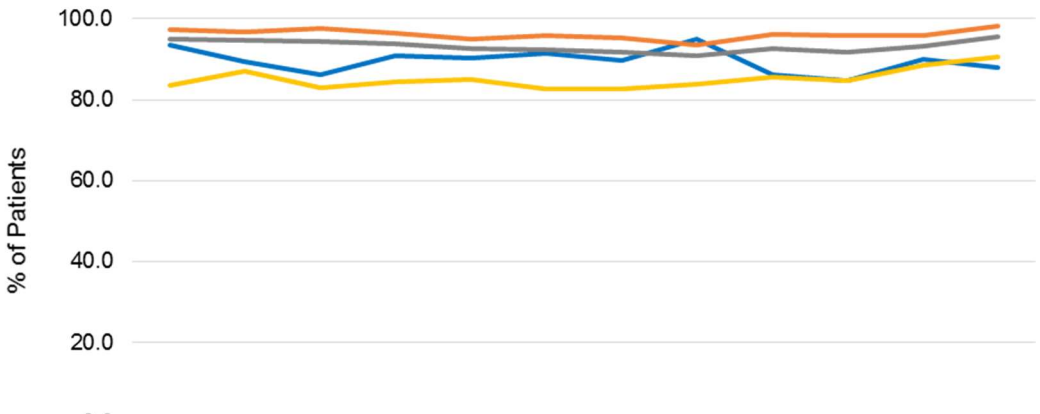
** Indicators of adequacy of dialysis are determined by URR and fractional clearance of urea (Kt/V) measurements*
† Indicators of iron stores are determined by serum ferritin and transferrin saturation measurements
^ Note that the latest available value for the year was used for all analyses.

5.5.1 Adequacy of Dialysis

98.6% of the HD patients were dialysed 3 times per week (see Table 5.5.1). The proportion of these patients with URR ≥ 65% or fractional clearance of urea (Kt/V) ≥ 1.2 was above 90% in the period from 2005 to 2016. The proportion of patients

who met adequacy of dialysis guidelines was 98.3% in VWOs but was lower at 90.6% in the private dialysis centres and 88.0% in RHs in 2016 (Figure 5.5.1.1).

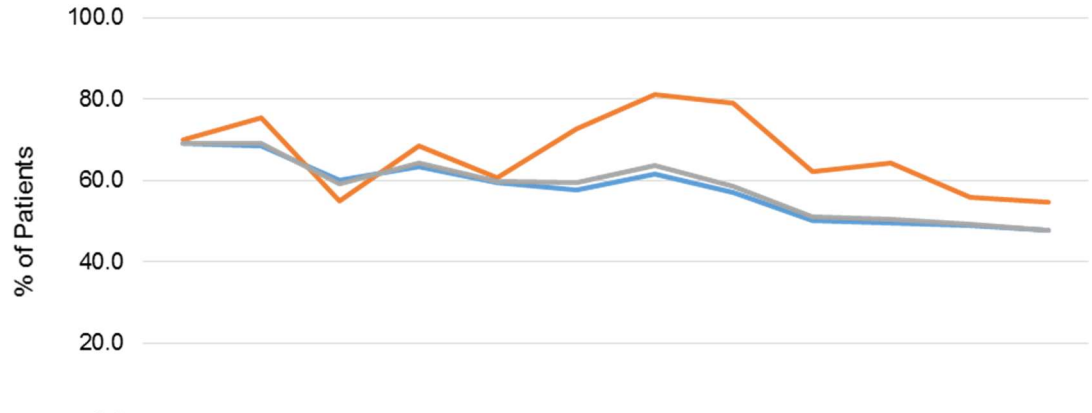
Figure 5.5.1.1: Percentage of HD Patients with URR ≥ 65% or Kt/V ≥ 1.2



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RH	93.6	89.4	86.1	90.9	90.4	91.6	89.7	94.9	86.2	84.7	89.9	88.0
VWO	97.5	96.7	97.6	96.5	95.0	95.8	95.4	93.7	96.2	96.0	96.0	98.3
PTE	83.5	87.0	83.1	84.4	85.1	82.7	82.7	83.9	85.5	84.7	88.4	90.6
ALL	95.0	94.6	94.3	93.7	92.6	92.4	91.9	91.0	92.6	91.9	93.3	95.5

Among all prevalent patients on PD, the proportion of patients with Kt/V ≥ 2 ranged between 47.9% and 69.2% in the period from 2005 to 2016. The proportion of patients who met adequacy guidelines was higher in the VWOs (54.5%) than the RHs (47.7%) in 2016 (Figure 5.5.1.2).

Figure 5.5.1.2: Percentage of PD Patients with Kt/V ≥ 2

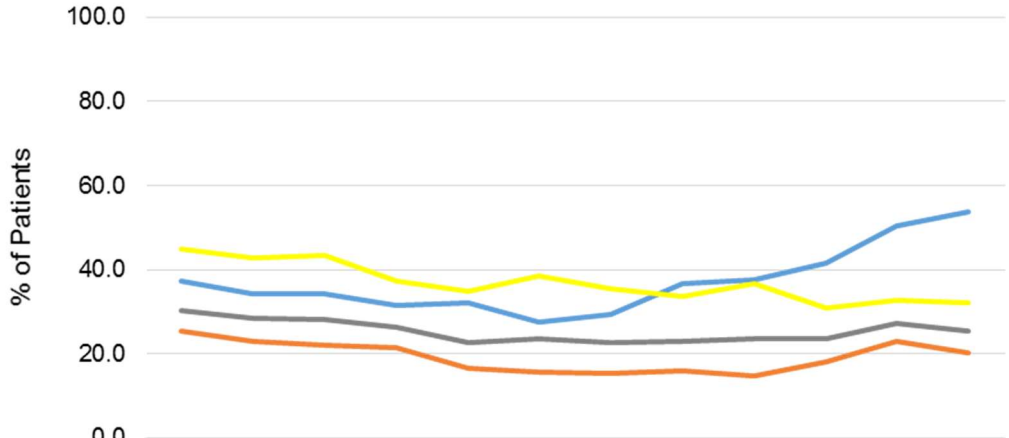


	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RH	69.0	68.5	60.0	63.4	59.4	57.8	61.7	57.2	50.2	49.6	49.0	47.7
VWO	69.9	75.4	55.0	68.4	60.7	72.6	81.3	78.9	62.2	64.3	56.0	54.5
ALL	69.2	69.1	59.1	64.4	59.6	59.6	63.6	58.7	51.0	50.4	49.3	47.9

5.5.2 Management of Anaemia (Hb < 10 g/dL)

Overall, the proportion of prevalent HD patients with ESA and Hb level below 10 g/dl decreased from 30.3% in 2005 to 25.3% in year 2016. The proportion of anaemic patients was highest in the RHs (53.7%) and lowest among the VWOs (20.3%) in 2016 (Figure 5.5.2.1).

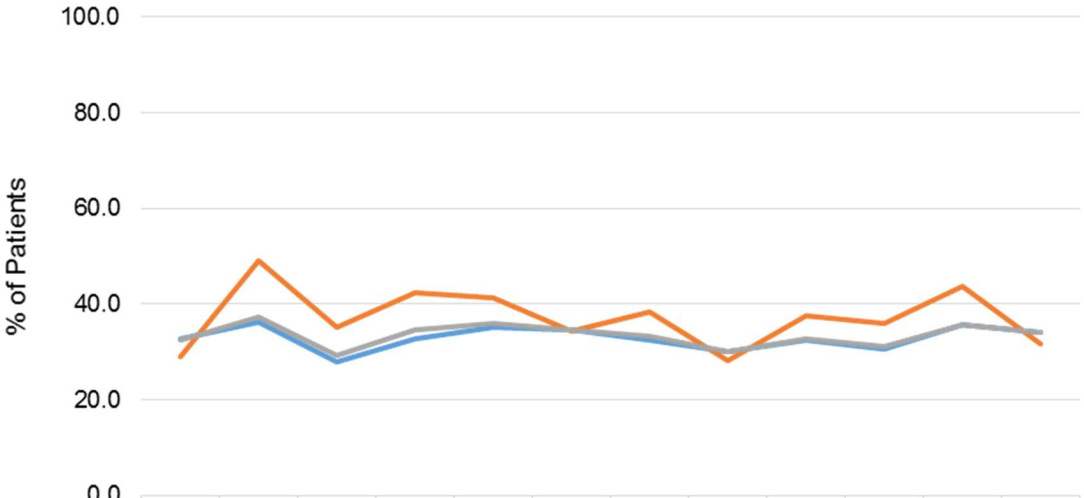
Figure 5.5.2.1: Percentage of HD Patients with Hb < 10 g/dl among those with ESA



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RH	37.4	34.4	34.1	31.6	32.1	27.5	29.5	36.7	37.7	41.6	50.5	53.7
VWO	25.3	22.9	22.1	21.6	16.6	15.6	15.3	16.1	14.6	18.1	22.9	20.3
PTE	44.8	42.7	43.4	37.2	34.9	38.4	35.6	33.6	36.8	31.0	32.8	32.2
ALL	30.3	28.4	28.1	26.4	22.7	23.5	22.8	23.0	23.6	23.5	27.2	25.3

Overall, the proportion of prevalent PD patients with ESA and Hb level below 10 g/dl ranged from about 29.3% to 37.2% in the period from 2005 to 2016 (Figure 5.5.2.2).

Figure 5.5.2.2: Percentage of PD Patients with ESA and Hb < 10 g/dl

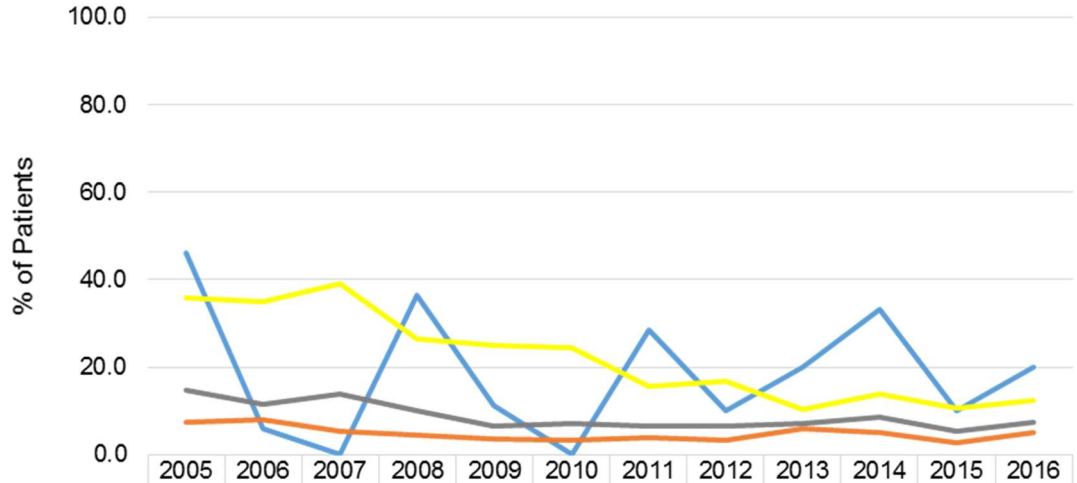


	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RH	32.9	36.1	28.0	32.9	35.1	34.8	32.6	30.2	32.6	30.6	35.6	34.1
VWO	29.0	49.2	35.2	42.5	41.3	34.4	38.5	28.2	37.5	36.1	43.8	31.8
ALL	32.5	37.2	29.3	34.5	36.0	34.7	33.3	30.0	32.8	31.1	35.8	34.1

** PTE patients not presented due to small counts*

Overall, the proportion of prevalent HD patients without ESA and Hb level below 10 g/dl decreased from 14.7% in 2005 to 7.4% in 2016 (Figure 5.5.2.3).

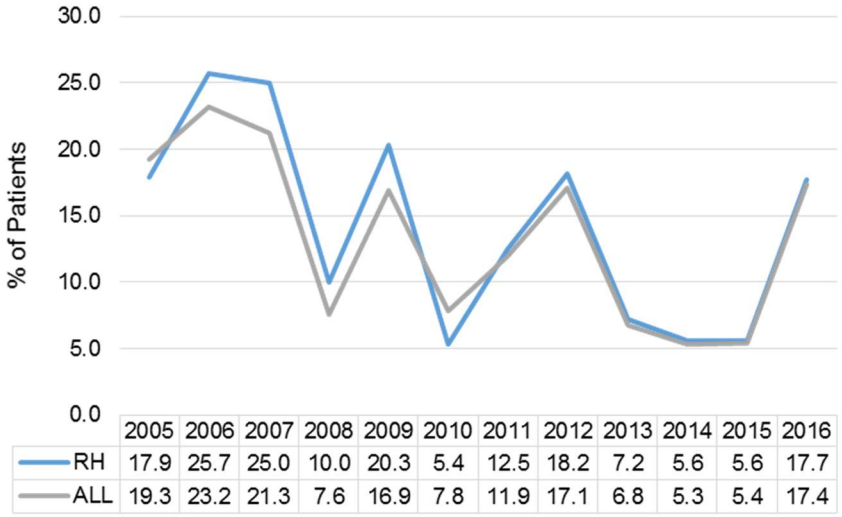
Figure 5.5.2.3: Percentage of HD Patients without ESA and Hb < 10 g/dl



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RH	46.2	5.9	0.0	36.4	11.1	0.0	28.6	10.0	20.0	33.3	10.0	20.0
VWO	7.5	8.1	5.4	4.6	3.4	3.4	3.9	3.1	5.8	5.2	2.8	5.2
PTE	35.9	35.0	39.0	26.6	25.0	24.4	15.5	16.7	10.3	14.0	10.7	12.4
ALL	14.7	11.4	13.9	10.2	6.5	7.2	6.5	6.6	7.2	8.6	5.5	7.4

Overall, the proportion of prevalent PD patients without ESA and Hb level below 10 g/dl fluctuated between 5.3% and 23.2% in the period 2005 to 2016 (Figure 5.5.2.4).

Figure 5.5.2.4: Percentage of PD Patients without ESA and Hb < 10 g/dl



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RH	17.9	25.7	25.0	10.0	20.3	5.4	12.5	18.2	7.2	5.6	5.6	17.7
ALL	19.3	23.2	21.3	7.6	16.9	7.8	11.9	17.1	6.8	5.3	5.4	17.4

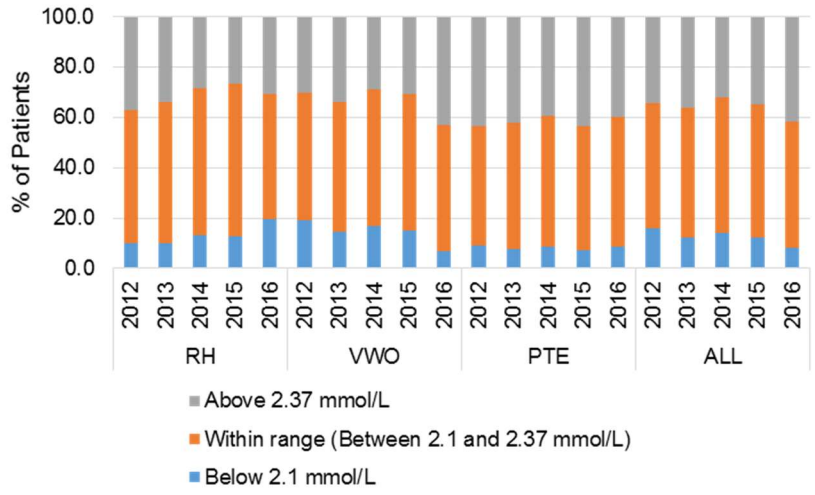
** VWO and PTE patients not presented due to small counts*

5.5.3 Management of Mineral and Bone Disease

5.5.3.1 Calcium

The overall proportion of prevalent HD patients, with corrected serum calcium level between 2.10 and 2.37 mmol/L, was about 50% which was similar for the different settings in year 2016 (Figure 5.5.3.1.1).

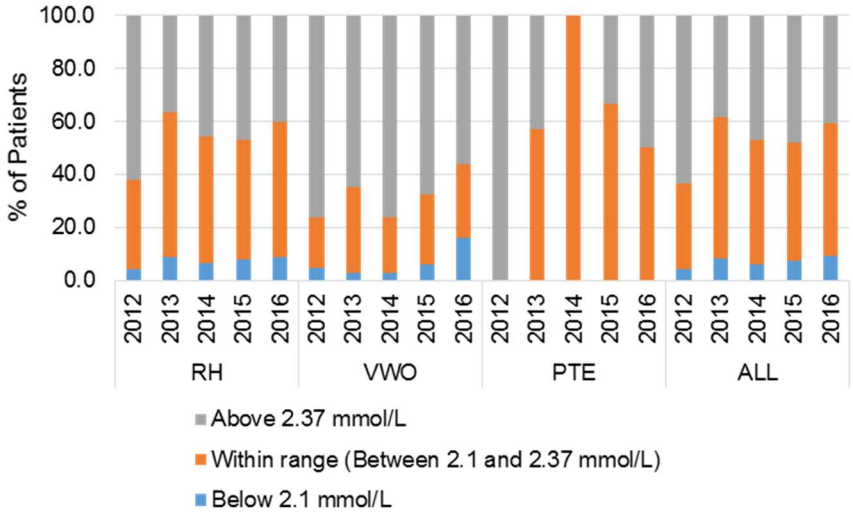
Figure 5.5.3.1.1: Distribution of corrected serum calcium among HD patients



** Only data based on last 5 years are presented due to complexity in the graphic visualisation*

The overall proportion of prevalent PD patients, with corrected serum calcium level between 2.10 and 2.37 mmol/L, ranged from 28.0% in VWOs and 51.6% in RHs in year 2016. (Figure 5.5.3.1.2).

Figure 5.5.3.1.2: Distribution of corrected serum calcium among PD patients

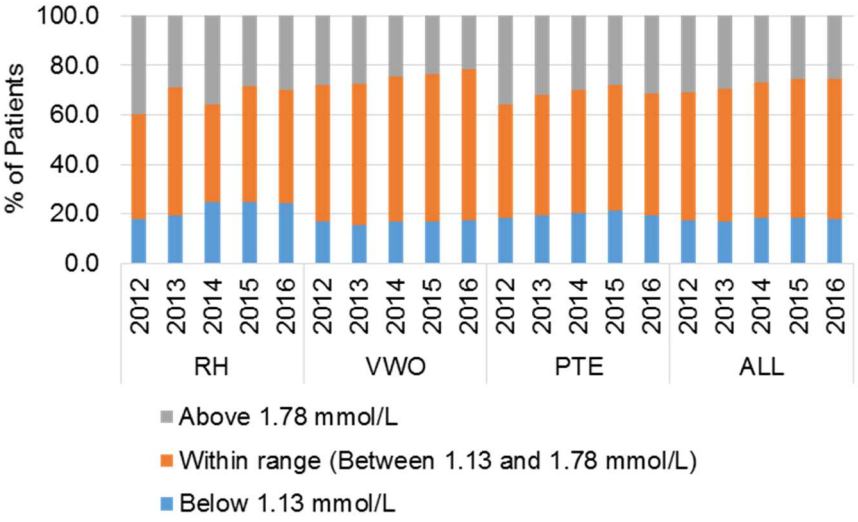


** Only data based on last 5 years are presented due to complexity in the graphic visualisation*

5.5.3.2 Serum Phosphate

The overall proportion of prevalent HD patients with serum phosphate between 1.13 and 1.78 mmol/L ranged from 51.4 to 56.8% in the period from 2012 to 2016 (Figure 5.5.3.2.1). In year 2016, the proportion of patients with serum phosphate level within range was highest among patients in the VWO centres (61.2%), and lowest among patients in the RHs (49.7%).

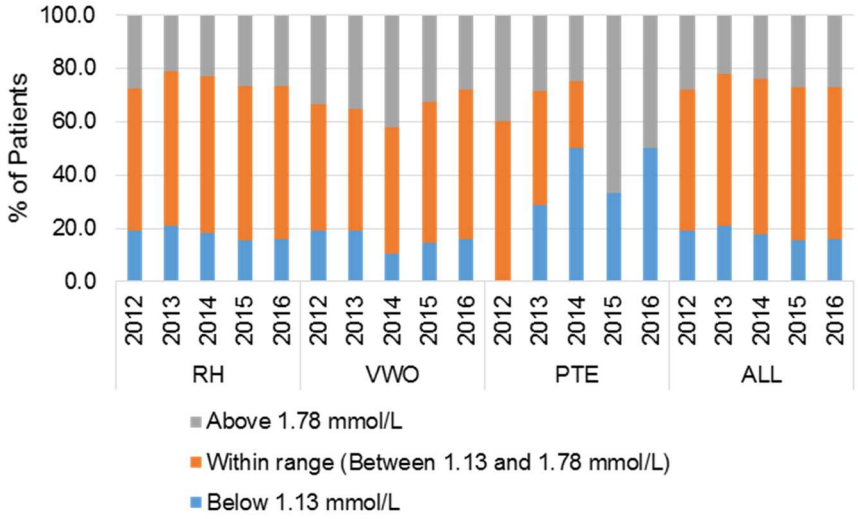
Figure 5.5.3.2.1: Distribution of Serum phosphate among HD Patients



** Only data based on last 5 years are presented due to complexity in the graphic visualisation*

The overall proportion of prevalent PD patients with serum phosphate between 1.13 and 1.78 mmol/L ranged from 53.0% to 58.1% in the period from 2012 to 2016 (Figure 5.5.3.2.2). In year 2016, the proportion of patients with serum phosphate level within range was 56.0% in VWOs and 57.4% in RHs.

Figure 5.5.3.2.2: Distribution of Serum phosphate among PD Patients

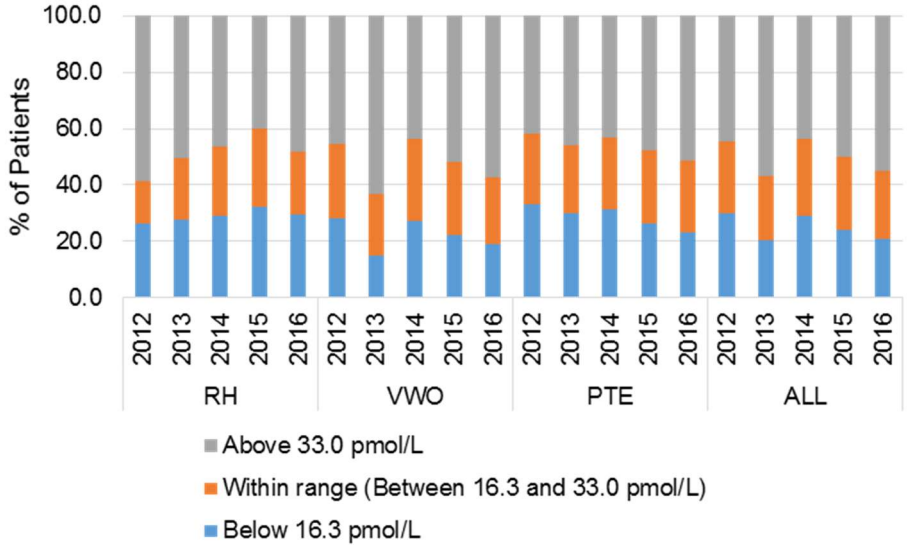


** Only data based on last 5 years are presented due to complexity in the graphic visualisation*

5.5.3.3 Serum Intact Parathyroid Hormone

The overall proportion of prevalent HD patients with serum iPTH level between 16.3 and 33.0 pmol/L ranged from 22.5% to 27.8% in the period from 2012 to 2016 (Figure 5.5.3.3.1). In year 2016, the private dialysis centres had the highest proportion of patients within this range (25.4%) while both RHs and VWOs had lower proportion (22.4% and 23.4% respectively).

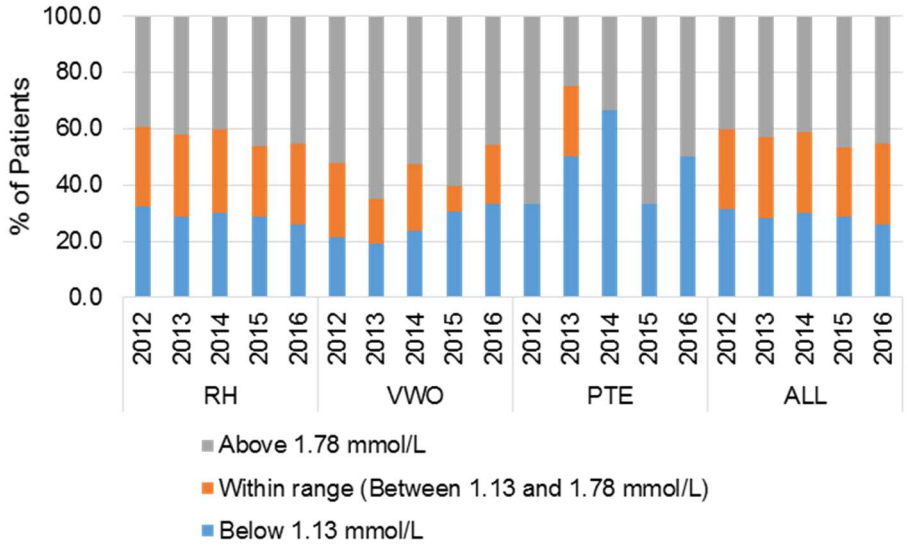
Figure 5.5.3.3.1: Distribution of serum iPTH among HD Patients



** Only data based on last 5 years are presented due to complexity in the graphic visualisation*

The overall proportion of prevalent PD patients with serum iPTH level between 16.3 and 33.0 pmol/L ranged from 24.5% to 29.1% in the period from 2012 to 2016 (Figure 5.5.3.3.2). In year 2016, proportion of PD patients within serum iPTH level within range was 20.8% in the VWOs and 29.0% in the RHs.

Figure 5.5.3.3.2: Distribution of serum iPTH among PD Patients



** Only data based on last 5 years are presented due to complexity in the graphic visualisation*

5.6 Incidence of Kidney Transplantation

The annual number of new kidney transplants increased from 84 in 1999 to 125 in 2006 but dropped to 64 in 2012. However, the number of kidney transplants seemed to increase from 2013 onwards, standing at 93 in year 2016. The corresponding age-standardised incidence rates increased from 20.6 pmp in 1999 to 27.0 pmp in 2006 but dropped to 13.9 pmp in 2012. The ASR for kidney transplants was 17.8 pmp in 2016. (Table 5.6.1). The number of incident transplant patients was at one of its lowest in 2003 for the period from 1999 to 2016. This was likely due to the SARS epidemic in Singapore that disrupted the provision of elective medical services.

Table 5.6.1: Number and Rates of Incident Kidney Transplantation

Year	No.	CR*	ASR*	ASR - 95% C.I.
1999	84	26.0	20.6	19.2-22.1
2000	83	25.4	20.5	19.1-21.9
2001	107	32.2	24.2	22.7-25.7
2002	82	24.2	18.7	17.4-20.0
2003	65	19.3	15.7	14.4-16.9
2004†	103	30.2	22.9	21.5-24.4
2005	118	34.0	26.3	24.8-27.8
2006	125	35.5	27.0	25.5-28.6
2007	112	31.3	24.5	23.0-26.0
2008†	104	28.6	23.0	21.5-24.4
2009	97	26.0	19.8	18.5-21.0
2010	87	23.1	18.2	17.0-19.5
2011	92	24.3	17.7	16.5-18.9
2012	64	16.8	13.9	12.7-15.0
2013	88	22.9	17.6	16.4-18.8
2014	76	19.6	15.8	14.5-17.0
2015	90	23.1	17.8	16.5-19.0
2016	93	23.6	17.8	16.6-19.0

** Crude rates (CR) and age-standardised rates (ASR) are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

† (a) The Human Organ Transplant Act (HOTA) was passed in 1987 to allow for transplantation of deceased donor kidneys removed from those who died in a hospital as a result of an accident and had chosen not to opt out of donating their organs prior to their deaths.[1]

(b) HOTA was amended in January 2004 to allow (i) transplantation of liver, heart and cornea, (ii) organ donation from donors with non-accidental causes of death and (iii) organ donation from living (both related and unrelated) organ donors.[1]

(c) HOTA was amended in August 2008 to include Muslim organ donors.[2]

(d) HOTA was amended in March 2009 to remove the upper age limit for potential deceased donors.

Note that the numbers include Singapore residents who received kidney transplantation overseas, but not foreigners receiving kidney transplantation in Singapore.

[1] Shum E, Chern A. Amendment of The Human Organ Transplant Act. Ann Acad Med Singapore. 2006; 35 428 - 32
[2] Ministry of Health. 10 February 2009. "Dental Care, HOTA, Infection Control and Cloning".
Website: http://www.moh.gov.sg/mohcorp/speeches.aspx?id=20980. Accessed on: 22 July 2010

Males constituted a higher percentage of incident kidney transplant recipients for all years (47.6% to 66.4%) except in 2002 and 2004 (Table 5.6.2). The corresponding rates are shown in the same table.

Table 5.6.2: Number and Rates of Incident Kidney Transplantation by Gender

	Males				Females			
Year	No.	%	CR*	ASR*	No.	%	CR*	ASR*
1999	44	52.4	27.2	21.7	40	47.6	24.8	19.5
2000	43	51.8	26.3	21.8	40	48.2	24.4	19.3
2001	71	66.4	42.8	32.6	36	33.6	21.6	16.1
2002	39	47.6	23.2	18.4	43	52.4	25.3	19.1
2003	42	64.6	25.1	19.8	23	35.4	13.6	11.5
2004	51	49.5	30.1	22.8	52	50.5	30.3	23.2
2005	68	57.6	39.5	30.4	50	42.4	28.6	22.3
2006	66	52.8	37.8	29.2	59	47.2	33.2	25.0
2007	58	51.8	32.7	25.9	54	48.2	29.9	23.2
2008	60	57.7	33.3	26.5	44	42.3	23.9	19.7
2009	52	53.6	28.2	21.0	45	46.4	23.8	18.5
2010	44	50.6	23.6	18.5	43	49.4	22.5	18.1
2011	53	57.6	28.4	20.0	39	42.4	20.3	15.6
2012	33	51.6	17.6	14.5	31	48.4	16.0	13.3
2013	51	58.0	27.0	20.8	37	42.0	18.9	14.4
2014	40	52.6	21.0	15.7	36	47.4	18.3	15.8
2015	51	56.7	26.6	20.3	39	43.3	19.6	15.3
2016	48	51.6	24.9	17.8	45	48.4	22.5	17.8

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

It was observed that Malay patients who received transplants was at one of its highest in 2008 (19.6%) and was possibly related to the HOTA amendment in that year. The corresponding rates are shown in Table 5.6.3.

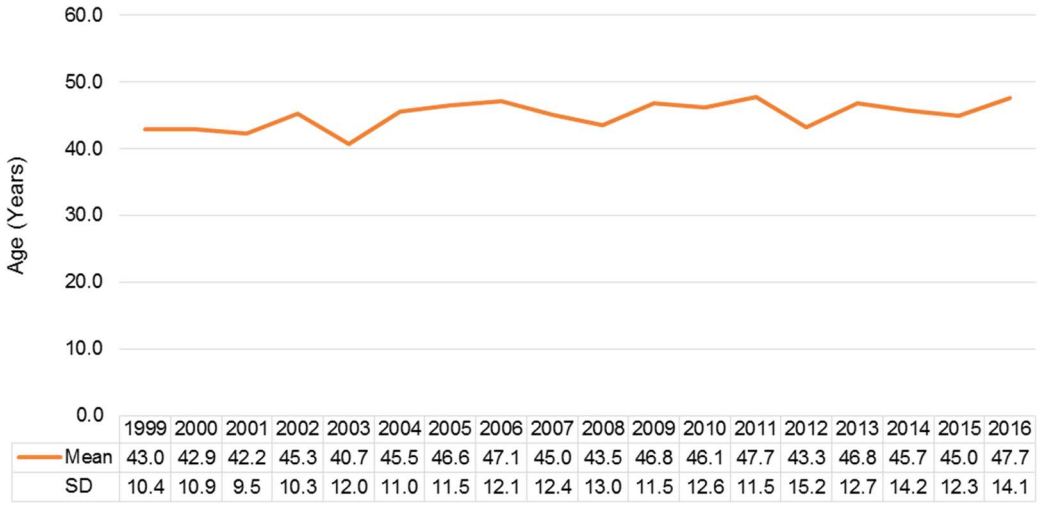
Table 5.6.3: Number and Rates of Incident Kidney Transplantation by Ethnic Group

	Chinese				Malays				Indians			
Year	**No.**	**%**	**CR***	**ASR***	**No.**	**%**	**CR***	**ASR***	**No.**	**%**	**CR***	**ASR***
1999	71	85.5	28.6	22.2	6	7.2	13.3	10.6	6	7.2	23.7	18.1
2000	74	90.2	29.4	23.1	5	6.1	11.0	8.8	3	3.7	11.6	11.3
2001	85	81.0	33.3	24.5	11	10.5	23.8	19.2	9	8.6	34.2	25.6
2002	70	85.4	27.0	19.8	10	12.2	21.4	18.7	2	2.4	7.4	8.1
2003	41	67.2	15.9	12.2	9	14.8	19.2	17.7	11	18.0	40.8	33.0
2004	88	86.3	33.8	25.3	8	7.8	16.8	13.1	6	5.9	21.6	16.7
2005	109	93.2	41.5	30.8	6	5.1	12.5	10.9	2	1.7	6.9	5.1
2006	97	80.2	36.5	27.1	14	11.6	28.8	21.7	10	8.3	33.0	29.8
2007	90	81.8	33.5	25.3	13	11.8	26.5	22.5	7	6.4	22.3	16.0
2008	73	71.6	26.8	20.5	20	19.6	40.4	34.1	9	8.8	27.8	26.0
2009	74	78.7	26.7	19.7	14	14.9	28.0	21.7	6	6.4	17.5	11.6
2010	68	80.0	24.3	18.3	13	15.3	25.8	21.5	4	4.7	11.5	11.4
2011	69	76.7	24.6	17.1	11	12.2	21.7	17.7	10	11.1	28.7	21.9
2012	47	74.6	16.6	13.4	6	9.5	11.8	9.6	10	15.9	28.5	25.4
2013	64	75.3	22.4	17.2	14	16.5	27.3	21.9	7	8.2	19.9	16.7
2014	53	71.6	18.4	13.5	14	18.9	27.1	23.8	7	9.5	19.8	17.1
2015	58	67.4	20.0	14.7	17	19.8	32.6	28.1	11	12.8	31.0	24.7
2016	73	82.0	25.0	18.5	10	11.2	19.0	16.0	6	6.7	16.8	12.9

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

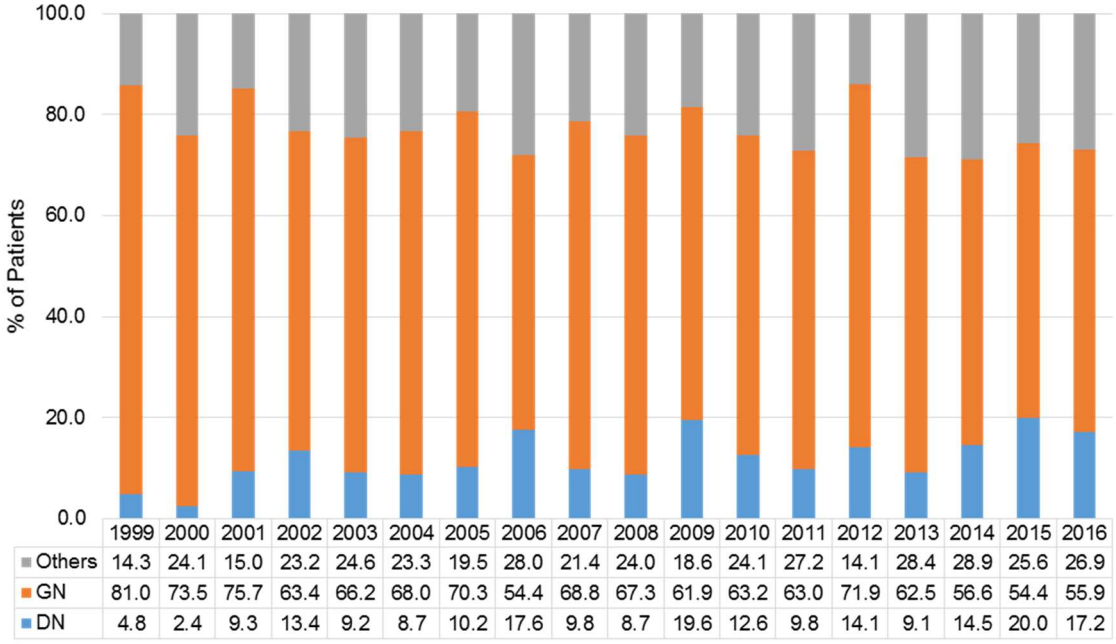
The mean age of transplant patients peaked at 47.7 years in both 2011 and 2016. (Figure 5.6.1).

Figure 5.6.1: Average Age of Incident Kidney Transplant Patients



For the period from 1999 to 2016, it was observed that GN was the main contributor of renal failure. The percentage of incident transplant patients with GN as the etiology of renal failure ranged from 54.4% to 81.0% in the period 1999 to 2016 (Figure 5.6.2).

Figure 5.6.2: Percentage of Incident Kidney Transplantation by Etiology



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Others	14.3	24.1	15.0	23.2	24.6	23.3	19.5	28.0	21.4	24.0	18.6	24.1	27.2	14.1	28.4	28.9	25.6	26.9
GN	81.0	73.5	75.7	63.4	66.2	68.0	70.3	54.4	68.8	67.3	61.9	63.2	63.0	71.9	62.5	56.6	54.4	55.9
DN	4.8	2.4	9.3	13.4	9.2	8.7	10.2	17.6	9.8	8.7	19.6	12.6	9.8	14.1	9.1	14.5	20.0	17.2

From Table 5.6.4, new transplants performed overseas ranged from 20.0% to 46.2% in the period from 1999 to 2016. There was an increasing trend in overseas transplants from 1999 to 2003, followed by a general decreasing trend since 2004. Cadaveric transplants performed locally ranged from 22.4% to 64.3% in the period 1999 to 2016.

Table 5.6.4: Number and Percentage of Incident Kidney Transplantation by Location and Donor Characteristics

Year	Local TX				Overseas TX		All
	Living-Donor		Deceased-Donor				
	No.	%	No.	%	No.	%	No.
1999	13	15.5	54	64.3	17	20.2	84
2000	10	12.0	44	53.0	29	34.9	83
2001	25	23.4	46	43.0	36	33.6	107
2002	18	22.0	30	36.6	34	41.5	82
2003	17	26.2	18	27.7	30	46.2	65
2004	28	27.2	32	31.1	43	41.7	103
2005	24	20.3	43	36.4	51	43.2	118
2006	30	24.0	56	44.8	39	31.2	125
2007	37	33.0	46	41.1	29	25.9	112
2008	27	26.0	46	44.2	31	29.8	104
2009	28	28.9	41	42.3	28	28.9	97
2010	25	28.7	36	41.4	26	29.9	87
2011	31	33.7	36	39.1	25	27.2	92
2012	28	43.8	23	35.9	13	20.3	64
2013	35	39.8	34	38.6	19	21.6	88
2014	41	53.9	17	22.4	18	23.7	76
2015	40	44.4	32	35.6	18	20.0	90
2016	32	34.4	40	43.0	21	22.6	93

5.7 Prevalence of Kidney Transplantation

In total, there were 1500 prevalent transplants at the end of 2016. The age-standardised prevalence rates increased from 207.2 pmp in 1999 to 259.3 pmp in 2016 (Table 5.7.1).

Table 5.7.1: Number and Rates of Prevalent Kidney Transplantation

Year	No.	CR*	ASR*	ASR - 95% C.I.
1999	846	261.9	207.2	202.7-211.8
2000	890	271.9	215.8	211.2-220.4
2001	964	289.8	227.3	222.7-232.0
2002	978	289.1	224.1	219.6-228.6
2003	1005	298.5	228.8	224.2-233.3
2004	1053	308.5	234.1	229.5-238.6
2005	1120	323	243.2	238.6-247.8
2006	1190	337.5	253.8	249.1-258.4
2007	1242	346.7	258.3	253.6-262.9
2008	1287	353.3	264.0	259.4-268.7
2009	1337	358.1	266.2	261.6-270.8
2010	1378	365.4	268.1	263.5-272.7
2011	1420	374.7	270.1	265.5-274.6
2012	1422	372.5	265.3	260.8-269.7
2013	1451	377.4	264.6	260.2-269.1
2014	1454	375.6	260.5	256.2-264.9
2015	1474	377.7	258.7	254.4-263.0
2016	1500	381.3	259.3	255.0-263.6

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

Overall, there were more males with transplants (Table 5.7.2).

Table 5.7.2: Number and Rates of Prevalent Kidney Transplantation by Gender

	Males				Females			
Year	**No.**	**%**	**CR***	**ASR***	**No.**	**%**	**CR***	**ASR***
1999	451	53.3	279.3	225.6	395	46.7	244.5	189.3
2000	480	53.9	293.6	237.4	410	46.1	250.2	194.5
2001	531	55.1	320.1	255.1	433	44.9	259.6	200.2
2002	533	54.5	316.4	249.9	445	45.5	261.9	199.2
2003	554	55.1	331.0	256.7	451	44.9	266.4	201.8
2004	578	54.9	340.9	260.5	475	45.1	276.5	208.7
2005	616	55.0	357.9	270.6	504	45.0	288.6	217.0
2006	653	54.9	373.5	282.7	537	45.1	302.1	226.2
2007	675	54.3	380.1	284.3	567	45.7	313.8	233.7
2008	705	54.8	391.0	294.1	582	45.2	316.4	235.6
2009	728	54.5	394.7	294.0	609	45.5	322.4	239.6
2010	745	54.1	400.3	294.8	633	45.9	331.3	242.6
2011	761	53.6	407.3	293.2	659	46.4	343.1	248.3
2012	758	53.3	403.2	287.1	664	46.7	342.6	244.9
2013	770	53.1	407.1	285.0	681	46.9	348.7	245.8
2014	774	53.2	406.9	280.2	680	46.8	345.5	242.1
2015	789	53.5	411.7	279.1	685	46.5	344.9	239.4
2016	802	53.5	415.6	279.1	698	46.5	348.3	240.6

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

Among the three ethnic groups, Chinese comprised the highest proportion of transplant recipients. The proportion of Malay transplant recipients increased slightly over the years (Table 5.7.3).

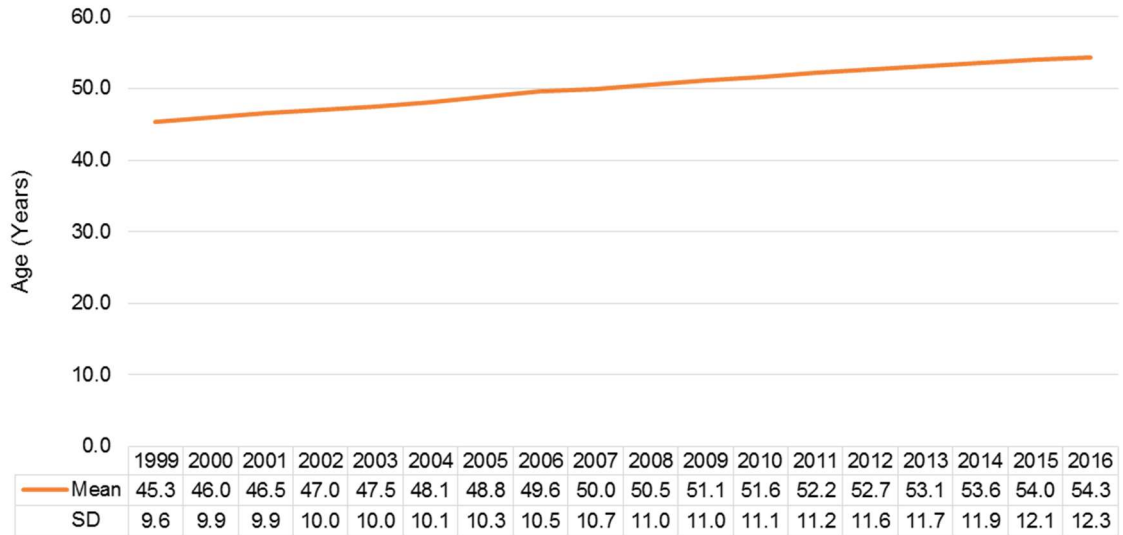
Table 5.7.3: Number and Rates of Prevalent Kidney Transplantation by Ethnic Group

	Chinese				Malays				Indians			
Year	**No.**	**%**	**CR***	**ASR***	**No.**	**%**	**CR***	**ASR***	**No.**	**%**	**CR***	**ASR***
1999	719	85.8	289.6	220.5	73	8.7	162.4	138.8	46	5.5	181.5	155.6
2000	760	86.3	302.3	231.0	75	8.5	164.8	141.2	46	5.2	178.3	153.4
2001	819	85.8	320.9	242.0	82	8.6	177.5	152.6	53	5.6	201.5	171.1
2002	839	86.7	324.0	241.1	83	8.6	177.2	153.5	46	4.8	169.2	145.2
2003	852	86.0	331.2	243.1	85	8.6	181.0	156.6	54	5.4	200.2	167.9
2004	894	86.2	343.9	250.2	85	8.2	178.6	152.5	58	5.6	208.5	172.6
2005	957	86.7	364.3	262.7	89	8.1	185.1	151.4	58	5.3	199.3	165.8
2006	1012	86.3	381.0	273.5	95	8.1	195.5	157.9	65	5.5	214.5	180.7
2007	1048	85.8	390.1	276.9	102	8.3	208.0	168.5	72	5.9	229.8	192.8
2008	1074	84.8	394.6	279.5	114	9.0	230.2	186.7	79	6.2	244.4	213.5
2009	1109	84.5	400.3	281.2	125	9.5	250.0	203.1	79	6.0	230.1	201.2
2010	1140	84.3	408.0	282.7	132	9.8	261.9	209.1	81	6.0	232.8	204.5
2011	1169	84.0	416.3	282.5	136	9.8	268.6	216.8	87	6.3	249.4	212.5
2012	1166	83.7	411.8	276.7	135	9.7	265.0	210.9	92	6.6	262.1	221.8
2013	1183	83.3	414.5	275.0	144	10.1	280.9	220.8	93	6.5	264.6	221.2
2014	1179	82.9	410.2	269.1	148	10.4	286.5	222.5	95	6.7	269.1	221.2
2015	1186	82.5	409.0	265.1	155	10.8	297.5	230.1	97	6.7	273.3	215.6
2016	1203	82.9	411.5	264.6	154	10.6	304.2	238.6	94	6.5	277.4	209.8

** CR and ASR are expressed as per 1,000,000 residential population (DOS) and ASR are standardised to World Population.*

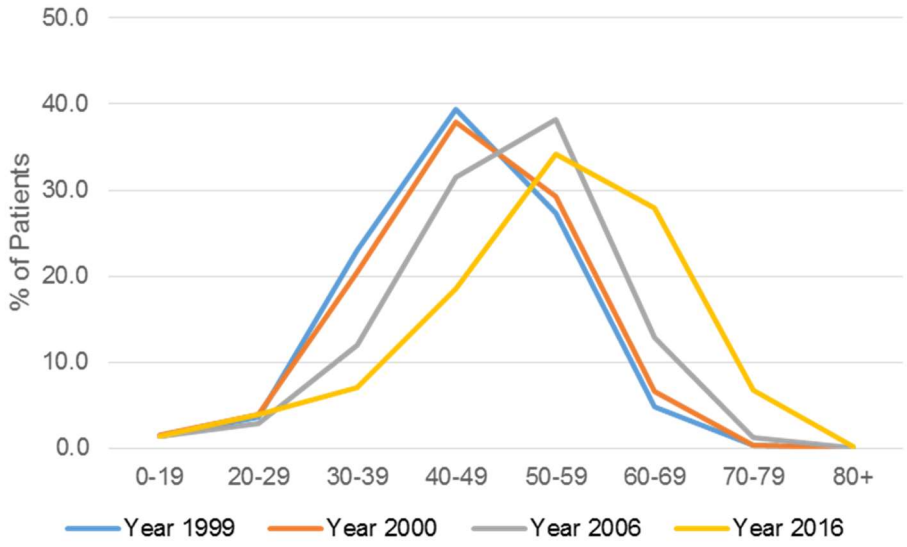
The mean age for prevalent renal transplant patients increased from 45.3 years in 1999 to 54.3 years in 2016 (Figure 5.7.1).

Figure 5.7.1: Average Age of Prevalent Kidney Transplant Patients



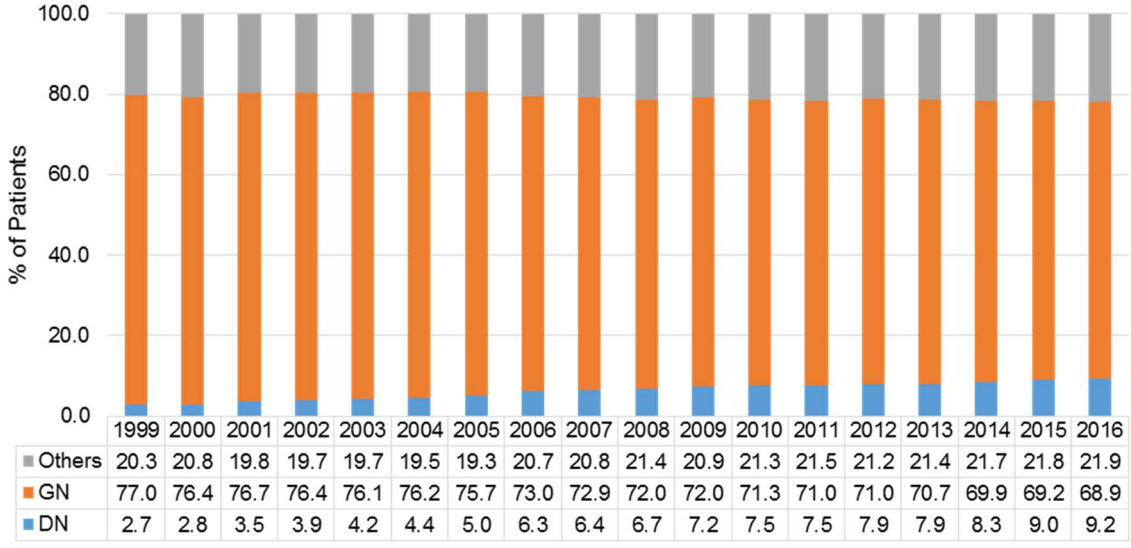
In line with the increase in median age of incident transplant patients, the prevalent transplant patients peaked at an older age in 2016 compared to in 1999 (Figure 5.7.2).

Figure 5.7.2: Percentage of Prevalent Kidney Transplantation by Age Groups



Overall, primary glomerulonephritis remained as the single main cause for CKD5 among prevalent kidney transplants (Figure 5.7.3).

Figure 5.7.3: Percentage of Prevalent Kidney Transplantation by Etiology



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Others	20.3	20.8	19.8	19.7	19.7	19.5	19.3	20.7	20.8	21.4	20.9	21.3	21.5	21.2	21.4	21.7	21.8	21.9
GN	77.0	76.4	76.7	76.4	76.1	76.2	75.7	73.0	72.9	72.0	72.0	71.3	71.0	71.0	70.7	69.9	69.2	68.9
DN	2.7	2.8	3.5	3.9	4.2	4.4	5.0	6.3	6.4	6.7	7.2	7.5	7.5	7.9	7.9	8.3	9.0	9.2

Prevalent transplants, which were performed overseas, constituted about 30% of all transplants in 1999-2016. Deceased-donor transplants made up about 40%-50% of the prevalent transplants in the same period (Table 5.7.4).

Table 5.7.4: Number and Percentage of Prevalent Kidney Transplantation by Location and Donor Characteristics

Year	Local TX				Overseas TX		All
	Living-Donor		Deceased-Donor				
	No.	%	No.	%	No.	%	No.
1999	185	21.9	442	52.2	219	25.9	846
2000	190	21.3	467	52.5	233	26.2	890
2001	210	21.8	495	51.3	259	26.9	964
2002	218	22.3	492	50.3	268	27.4	978
2003	233	23.2	487	48.5	285	28.4	1005
2004	250	23.7	496	47.1	307	29.2	1053
2005	266	23.8	510	45.5	344	30.7	1120
2006	284	23.9	539	45.3	367	30.8	1190
2007	312	25.1	556	44.8	374	30.1	1242
2008	329	25.6	568	44.1	390	30.3	1287
2009	350	26.2	583	43.6	404	30.2	1337
2010	363	26.3	592	43.0	423	30.7	1378
2011	388	27.3	602	42.4	430	30.3	1420
2012	404	28.4	589	41.4	429	30.2	1422
2013	429	29.6	591	40.7	431	29.7	1451
2014	455	31.3	571	39.3	428	29.4	1454
2015	480	32.6	570	38.7	424	28.8	1474
2016	490	32.7	585	39.0	425	28.3	1500

5.8 Survival of Kidney Transplantation

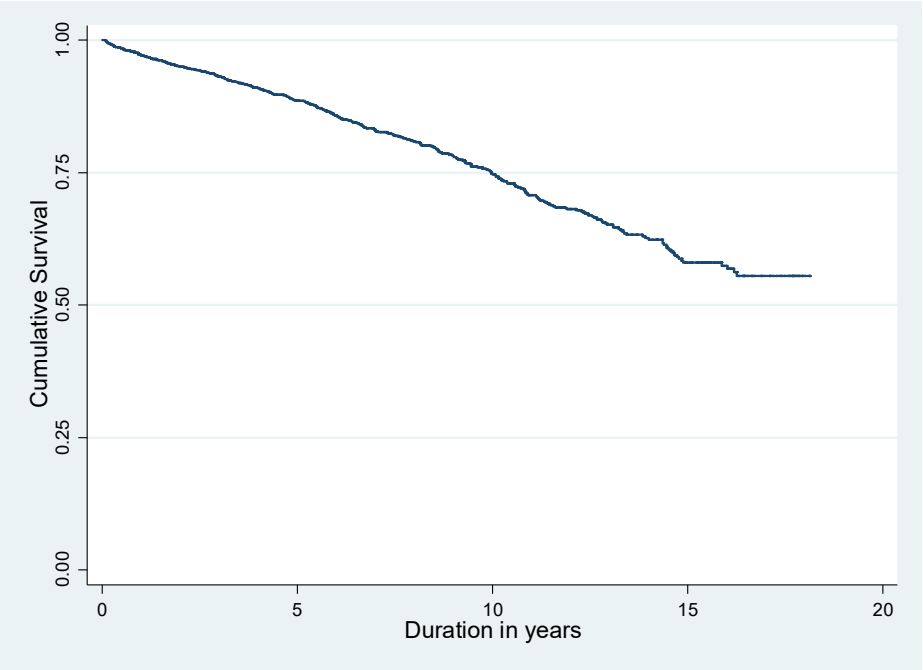
The chances of surviving 1 year and 5 years for transplanted patients were 98.2% and 93.4% respectively (Table 5.8.1 and Figure 5.8.1). The corresponding 1 and 5-year graft survivals were 97.1% and 88.6% respectively. Median survival was not reached for both graft and patient survival. In other words, more than 50% of the patients (grafts) survived by the end of the study period.

Table 5.8.1: Graft and Patient Survival

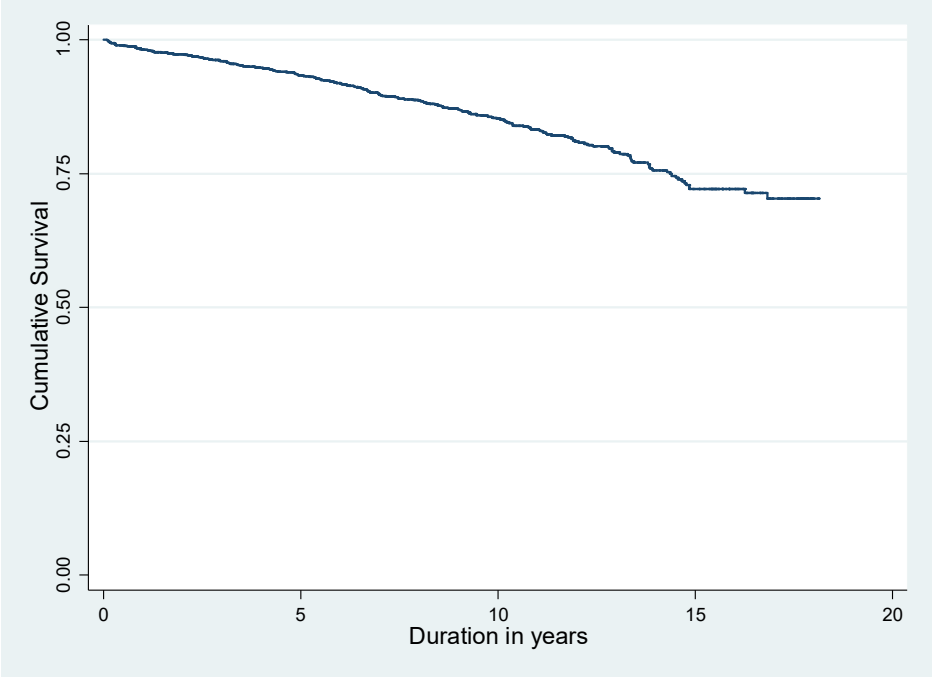
1999-2016	Graft	Patient
1 year survival (%)	97.1	98.2
5 year survival (%)	88.6	93.4
10 year survival (%)	74.8	85.3
Median survival (years)	Not reached	Not reached

Figure 5.8.1: Graft and Patient Survival

(a) Graft Survival



(b) Patient Survival



Graft and patient survival of kidney transplants for the 2 groups (based on types of renal transplant) are shown in Table 5.8.2 and Figure 5.8.2. Only grafts functioning beyond 30 days were included in the analysis. Out of the 1645 transplants, 44 (2.7%) did not survive beyond 30 days (Data not shown). Local living-donor transplants had better 5-year graft survival probability as compared to local deceased-donor transplants (Table 5.8.2).

Table 5.8.2: Graft and Patient Survival Stratified by Type of Kidney Transplantation

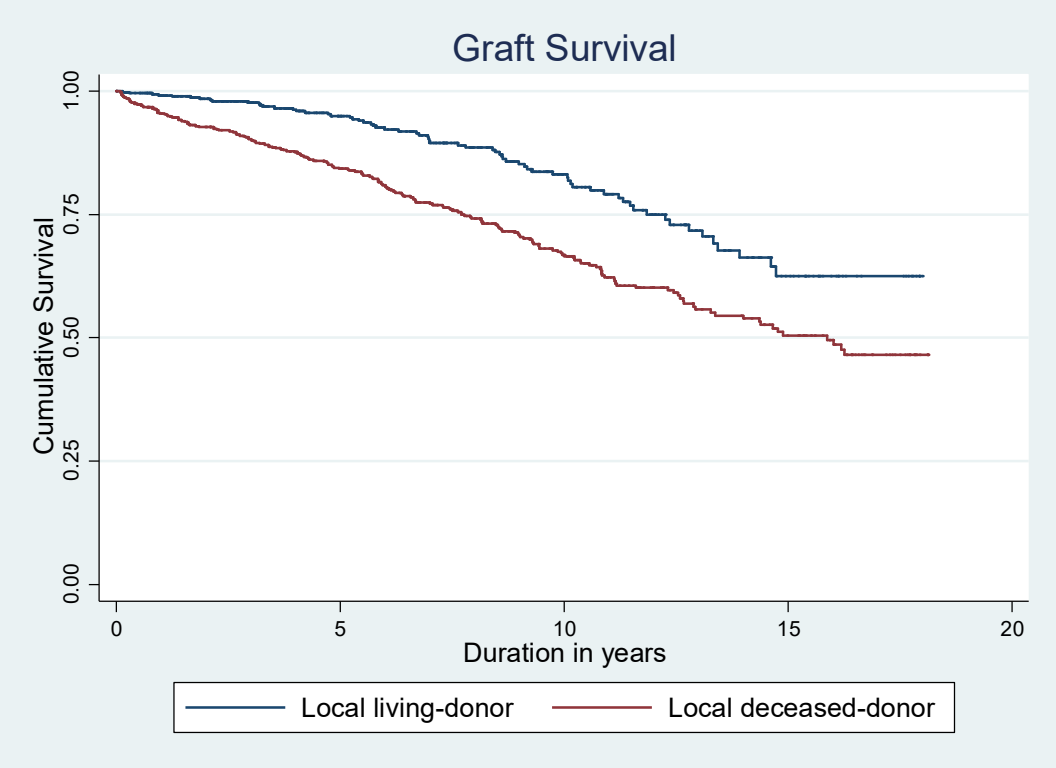
1999-2016 Graft Survival	Local Living-Donor	Local Deceased-Donor
1 year survival (%)	99.1	95.5
5 year survival (%)	95.0	84.3
10 year survival (%)	83.1	66.8
Median survival (years)	Not reached	15.9

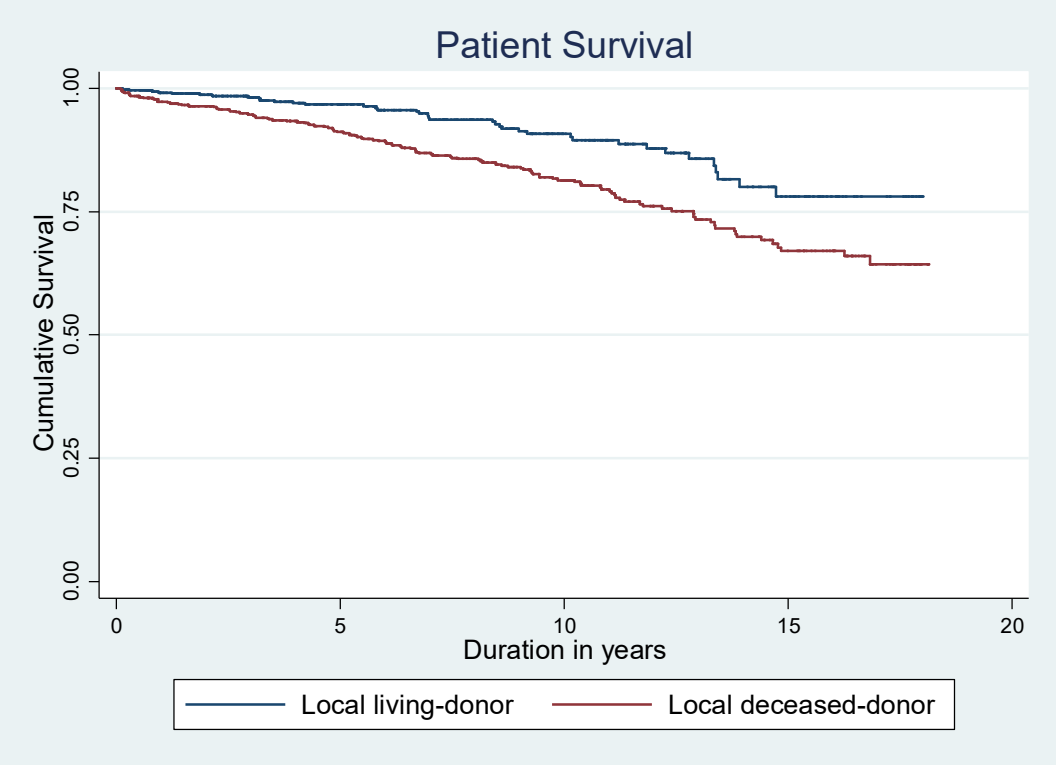
P-value: <0.001

1999-2016 Patient Survival	Local Living-Donor	Local Deceased-Donor
1 year survival (%)	99.1	97.3
5 year survival (%)	96.7	91.2
10 year survival (%)	90.8	81.4
Median survival (years)	Not reached	Not reached

P-value:< 0.001

Figure 5.8.2: Graft and Patient Survival Stratified by Type of Kidney Transplantation





Tables 5.8.3 to 5.8.11 compare graft and patient survival between diabetics and non-diabetics, presence of IHD, CVD, PVD, malignancy, whether patients present with any comorbidity, gender, ethnicity and age groups. The 5-year survival among patients without any co-morbidity was significant higher than that among patients with co-morbidity (95.3% versus 90.0%, p<0.001). There was a difference in patient survival comparing patients with and without DN (p=0.001), with and without IHD (p<0.001), patients with and without CVD (p=0.012), and patients with and without malignancy (p=0.03). In particular, there was no significant difference in patient survival among males and females (p=0.81), as well as among the three ethnic groups (p=0.42). Expectedly, patient survival was significantly lower among older recipients (p<0.001). Though there was no significant difference in patient survival in terms of gender and ethnicity, better survival was observed among the non-diabetics, and those aged below 60.

Table 5.8.3: Graft and Patient Survival Stratified by Etiology

1999-2016 Graft Survival	DN	Non-DN
1 year survival (%)	96.8	97.2
5 year survival (%)	81.5	89.5
10 year survival (%)	65.2	76.0
Median survival (years)	12.8	Not reached

P-value: 0.001

1999-2016 Patient Survival	DN	Non-DN
1 year survival (%)	97.9	98.2
5 year survival (%)	86.6	94.3
10 year survival (%)	76.6	86.3
Median survival (years)	Not reached	Not reached

P-value: 0.001

Table 5.8.4: Survival by Presence of Ischaemic Heart Disease (IHD)

1999-2016 Graft Survival	IHD	Non-IHD
1 year survival (%)	97.8	97.2
5 year survival (%)	84.5	89.5
10 year survival (%)	68.8	75.9
Median survival (years)	13.1	Not reached

P-value: 0.006

1999-2016 Patient Survival	IHD	Non-IHD
1 year survival (%)	97.8	98.4

5 year survival (%)	88.2	94.4
10 year survival (%)	77.6	86.6
Median survival (years)	Not reached	Not reached

P-value < 0.001

Table 5.8.5: Survival by Presence of Cerebrovascular Disease (CVD)

1999-2016 Graft Survival	CVD	Non-CVD
1 year survival (%)	87.7	97.6
5 year survival (%)	83.8	89.1
10 year survival (%)	67.3	75.3
Median survival (years)	11.2	Not reached

P-value: 0.034

1999-2016 Patient Survival	CVD	Non-CVD
1 year survival (%)	92.9	98.5
5 year survival (%)	91.0	93.8
10 year survival (%)	78.6	85.7
Median survival (years)	14.8	Not reached

P-value: 0.012

Table 5.8.6: Survival by Presence of Peripheral Vascular Disease (PVD)

1999-2016 Graft Survival	PVD	Non-PVD
1 year survival (%)	90.5	97.3
5 year survival (%)	85.7	89.0
10 year survival (%)	76.2	75.1
Median survival (years)	12.9	Not reached

P-value: 0.49

1999-2016 Patient Survival	PVD	Non-PVD
1 year survival (%)	95.2	98.3
5 year survival (%)	90.5	93.8
10 year survival (%)	80.4	85.7
Median survival (years)	12.9	Not reached

P-value: 0.13

Table 5.8.7: Survival by Presence of Malignancy

1999-2016 Graft Survival	Malignancy	Non-Malignancy
1 year survival (%)	95.5	97.6

5 year survival (%)	79.1	89.9
10 year survival (%)	64.2	75.9
Median survival (years)	Not reached	Not reached

P-value: 0.15

1999-2016 Patient Survival	Malignancy	Non-Malignancy
1 year survival (%)	95.5	98.6
5 year survival (%)	84.2	94.7
10 year survival (%)	73.1	86.5
Median survival (years)	Not reached	Not reached

P-value: 0.03

Table 5.8.8: Survival by Presence of Comorbidity

1999-2016 Graft Survival	With Co-morbidity	No Co-morbidity
1 year survival (%)	96.9	97.3
5 year survival (%)	84.8	90.8
10 year survival (%)	70.8	77.0
Median survival (years)	14.8	Not reached

P-value < 0.001

1999-2016 Patient Survival	With Co-morbidity	No Co-morbidity
1 year survival (%)	97.9	98.3
5 year survival (%)	90.0	95.3
10 year survival (%)	81.7	87.3
Median survival (years)	Not reached	Not reached

P-value < 0.001

Table 5.8.9: Graft and Patient Survival Stratified by Gender

1999-2016 Graft Survival	Males	Females
1 year survival (%)	96.9	97.5
5 year survival (%)	87.9	89.5
10 year survival (%)	73.1	76.9
Median survival (years)	Not reached	Not reached

P-value: 0.15

1999-2016 Patient Survival	Males	Females
1 year survival (%)	98.0	98.3
5 year survival (%)	93.9	92.8
10 year survival (%)	85.8	84.7
Median survival (years)	Not reached	Not reached

P-value: 0.81

Table 5.8.10: Graft and Patient Survival Stratified by Ethnic Group

1999-2016 Graft Survival	Chinese	Malay	Indian
1 year survival (%)	97.3	96.2	97.4
5 year survival (%)	89.8	83.5	82.0
10 year survival (%)	76.7	65.9	61.5
Median survival (years)	Not reached	16.2	12.8

P-value: 0.002

1999-2016 Patient Survival	Chinese	Malay	Indian
1 year survival (%)	98.3	97.3	98.3
5 year survival (%)	93.8	92.5	90.0
10 year survival (%)	85.3	85.1	83.0
Median survival (years)	Not reached	Not reached	Not reached

P-value: 0.42

Table 5.8.11: Graft and Patient Survival Stratified by Age Groups

1999-2016 Graft Survival	Age < 60	Age ≥ 60
1 year survival (%)	97.3	95.1
5 year survival (%)	89.0	84.4
10 year survival (%)	75.3	68.4
Median survival (years)	Not reached	13.4

P-value: 0.005

1999-2016 Patient survival	Age < 60	Age ≥ 60
1 year survival (%)	98.3	95.9
5 year survival (%)	93.8	88.1
10 year survival (%)	86.1	73.5
Median survival (years)	Not reached	13.4

P-value: <0.001

Cox regression model (multivariable analysis) showed that age, diabetes as primary renal disease, ischaemic heart disease, as well as donor type were significant factors affecting time to death for kidney transplant patients (Table 5.8.12).

Table 5.8.12: Factors Associated with Death in Kidney Transplantation

Variables	Multivariable		
	HR	95% CI	p-value
Gender:			
-Male	Reference	-	
-Female	1.05	0.75-1.45	0.79
Ethnicity:			0.99
-Chinese	Reference	-	
-Malay	0.97	0.61-1.54	0.90
-Indian	0.97	0.50-1.85	0.92
Age groups:			
<60	Reference	-	
≥60	3.26	1.53-6.94	0.002
Diabetes as primary disease:			
-Absent	Reference	-	
-Present	2.39	1.26-4.53	0.008
Ischaemic Heart Disease:			
-Absent	Reference	-	
-Present	1.74	1.08-2.82	0.02
Cerebrovascular Disease:			
-Absent	Reference	-	
-Present	2.05	0.87-4.86	0.10
Peripheral Vascular Disease:			
-Absent	Reference	-	
-Present	1.32	0.39-4.47	0.66
Donor Type			
- Local living-donor	Reference	-	
- Local deceased-donor	2.67	1.77-4.03	<0.001

n=1,084

Cox regression model (multivariable analysis) showed that transplant patients (whether recipients from local living donors or local deceased donors) performed better in terms of survival as compared to the patients on dialysis only, after adjusting for age, diabetes as the etiology, ischaemic heart disease, cerebrovascular disease, and peripheral vascular disease (Table 5.8.13).

Table 5.8.13: Factors Associated with Death in Kidney Transplantation and Dialysis Patients

Variables	Multivariable		
	HR	95% CI	p-value
Treatment:			<0.001
-Dialysis	Reference	-	
-Local living donor	0.15	0.11-0.21	<0.001
-Local deceased donor	0.34	0.28-0.41	<0.001
Gender:			
-Male	Reference	-	
-Female	1.02	0.97-1.07	0.39
Ethnicity:			0.10
-Chinese	Reference	-	
-Malay	0.94	0.89-1.00	0.05
-Indian	0.95	0.86-1.04	0.24
Age groups:			
<60	Reference	-	
≥60	1.82	1.73-1.92	<0.001
Diabetes as primary disease:			
-Absent	Reference	-	
-Present	1.59	1.51-1.68	<0.001
Ischaemic Heart Disease:			
-Absent	Reference	-	
-Present	1.44	1.37-1.52	<0.001
Cerebrovascular Disease:			
-Absent	Reference	-	
-Present	1.32	1.25-1.39	<0.001
Peripheral Vascular Disease:			
-Absent	Reference	-	
-Present	1.40	1.32-1.49	<0.001

n=14,001

5.9 Service Providers for Prevalent Dialysis and Kidney Transplant Patients as on 31st December 2016

Majority of the prevalent HD patients were dialysed in centres run by VWOs (62.1%), 36.2% in private dialysis centres and 1.7% in RHs or their affiliated centres (Table 5.9.1).

For PD patients, the majority were cared for by the RHs (96.7%), 3.0% in VWOs and 0.2% in private centres.

Majority of the prevalent renal transplant patients were managed in RHs (89.7%), while 10.3% was managed in private dialysis centres or hospitals.

Table 5.9.1: Service Providers for Prevalent Dialysis and Transplant Patients as of 31st December 2016

Service Provider	HD		PD		TX	
	No.	%	No.	%	No.	%
Restructured Hospitals	100	1.7	796	96.7	1345	89.7
Voluntary Welfare Organisations	3629	62.1	25	3.0	0	0.0
Private Dialysis Centres/Hospitals	2114	36.2	2	0.2	154	10.3
Total	**5843**	**100**	**823**	**100**	**1499**	**100**

** denotes receipt of overseas transplantation in 2016.*

6 CONCLUSION

In its early stages, kidney disease may be asymptomatic, as the kidneys have a large reserve and a significant amount of damage need to occur before symptoms present. Renal replacement therapy in the form of dialysis or transplant is required when one's kidney function falls below 20% of the required capacity. In the case of dialysis, on top of direct costs incurred due to medical expenses, indirect costs can also arise from lifestyle changes that are required to accommodate the treatments.

It is therefore important for individuals with higher risk of CKD5 to take preventive action. Risk factors include hypertension, diabetes mellitus, and having a family history of kidney disease. Individuals with diabetes are at particularly high risk of developing diabetic nephropathy, currently the most common cause of CKD5 in Singapore and other parts of the world.

As the population of Singapore ages, the burden imposed by CKD5 and other chronic diseases will also increase, resulting in higher healthcare expenditure. This can be mitigated with the adoption of appropriate lifestyle modifications that can reduce one's risk of developing these conditions.

One can lower his or her chances of developing CKD5 by maintaining a diet that is low in sodium, fat, and sugar, and high in dietary fibre and whole grains. Exercise, at suitable levels, is also important in maintaining optimum bodily function.

For individuals at higher risk of developing CKD5 and/or its comorbidities, prevention is all the more important, as CKD5 affects not just the patient, but their families and caregivers as well. For individuals who have been diagnosed with kidney damage in the early stages, appropriate medication and diet can help to slow down and control the progression of kidney failure. For individuals who do not have existing medical conditions, health maintenance and screening remains important to reduce the risk of developing CKD5 and other chronic diseases.

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