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Island medicine: using data linkage to establish the kidney health of the population of Tasmania, Australia

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Abstract

Objective
To report (using linked laboratory data) the incidence, prevalence and geographic variation of chronic kidney disease (CKD) across the whole island population of Tasmania, Australia.

Methods
A retrospective cohort study (the Tasmanian Chronic Kidney Disease study (CKD.TASlink)) using linked data from five health and two pathology datasets from the island state of Tasmania, Australia between 1/1/2004 and 31/12/2017. We used data on 460,737 Tasmanian adults (aged 18 years and older, representing 86.8% of the state's population) who had a serum creatinine measured during the study period. We defined CKD as per Kidney Disease Outcomes Quality Initiative, requiring two measures of estimated glomerular filtration rate (eGFR) $<60\,mL/min/1.73\,m^2$, at least three months apart. Kidney replacement therapy (KRT) included dialysis or kidney transplantation.

Results
We identified 56,438 Tasmanians with CKD during the study period, equating to an age-standardised annual incidence of 1.0% and a prevalence of 6.5%. These figures were higher in women, older Tasmanians and people living in the North-West region of Tasmania. Testing for urinary albumin:creatinine ratio is increasing, with 28.5% of women and 30.8% of men with stage 3 CKD having both an eGFR and uACR in 2017. Use of KRT was consistently seen in >65% of Tasmanians with eGFR $<15\,mL/min/1.73\,m^2$.

Conclusion
There is geographic and gender variation in the incidence and prevalence of CKD, but it is reassuring to see that the majority of people with end-stage kidney failure are actually receiving treatment with dialysis or transplantation.

Keywords
Chronic kidney disease; dialysis; epidemiology; Tasmania; transplantation

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Background

The burden of chronic kidney disease (CKD) in Australia is increasing rapidly [1]. However, the financial cost of treating all people with kidney failure with dialysis or kidney transplantation is unsustainable and the community cost undesirable [2]. Early detection and intervention to prevent progression of CKD is relatively simple, cheap and a community priority. The population of Tasmania, an island state of Australia, has a high burden of chronic disease, including hypertension, obesity, cardiovascular disease and mental health problems [3]. All of these are known risk factors for the development of kidney disease, a progressive condition that once it is well established, it is (currently) not possible to reverse.

Kidney disease is diagnosed by measuring albumin in a urine sample (urine albumin:creatinine ratio, uACR) and creatinine in a blood test. The latter is then used to estimate glomerular filtration rate (eGFR), a measure of kidney function. CKD is defined as an abnormality of structure or function, present for $\geq$3 months, and is classified based on cause, eGFR and uACR categories. These categories allow standardised staging of CKD from stage one (normal, eGFR $\geq$90 mL/min/1.73 m^2) through stages two (mild decreased, eGFR 60–89 mL/min/1.73 m^2), three (moderate decrease, eGFR 30–59 mL/min/1.73 m^2), four (severe decreased, eGFR 15–29 mL/min/1.73 m^2) and stage five (kidney failure, eGFR $\leq$15 mL/min/1.73 m^2). Use of kidney replacement therapy (dialysis or kidney transplantation) occurs in stage five when appropriate.

Population estimates of CKD in Australia come from the Australian Health Survey (2011–12), where approximately 11,000 Australians each provided a single blood and urine sample. This population survey reported a higher prevalence of CKD per population in Tasmania than in any other state [3]. Albuminuria was present in 8.5% of Tasmanians compared with 7.7% in the rest of Australia, whilst eGFR $\leq$60 mL/min/1.73 m^2 occurred in 4.6% of Tasmanians compared with 3.5% in the rest of Australia [3]. Therefore, by standard definitions [4], Tasmania has the highest state prevalence of CKD in Australia.

Despite the increased prevalence of CKD, Tasmania has the lowest incidence of kidney failure treated with dialysis or transplantation (Kidney Replacement Therapy, KRT) of any Australian state or territory. In 2018 the incident rate of KRT was 87 per million population (pmp) in Tasmania, but 124pmp for Australia overall [5]. The prevalence rate of KRT was 939pmp, lower than national rate of 1026pmp, with the largest difference being use of dialysis where the prevalence was 400pmp in Tasmania compared to 536pmp in Australia overall [5]. Clearly there is a gap between the high rate of CKD reported by the Australian Health Survey and the low use of KRT. We first identified this gap in Tasmania in 2009 [6] and it was demonstrated again in 2011 by the Australian Institute of Health and Welfare report on total incidence of end-stage kidney disease. This report showed that for all people who die with kidney failure, Tasmanians were less likely to be treated with KRT than other Australians [7].

Tasmania is a small island state of approximately 68,000 km^2 located 250km to the south of mainland Australia. KRT facilities in Tasmania are currently provided in the North-West (Burnie), North (Launceston General Hospital and Kings Meadows) and South (Royal Hobart Hospital and Newtown), corresponding to resident adult (age 18 years and older) populations of approximately 87,000, 113,000 and 209,000 respectively [8]. All of Tasmania is classified as regional, remote or very remote according to Australian Standard Geographical Classification with distances between place of residence and dialysis facility up to 200km [9]. All acute transplant surgery takes place in Melbourne, Victoria.

To understand the relationship between kidney health and disease in the community and access to KRT in specific locations across the island state, we established a linked dataset containing both community and hospital data [10]. The aim of this present study was to confirm the state incidence and prevalence of CKD and use of KRT in Tasmania.

Methods

The Tasmanian Chronic Kidney Disease study (CKD.TASlink) was a retrospective cohort study that examined a dataset created by linkage of seven existing local health information datasets. Detailed methods and linked data obtained are available elsewhere [10]. Briefly, pathology data on 490,012 individuals (from birth) was obtained from community and hospital-based pathology providers between 1/1/2004 to 31/12/2017. Individuals were selected if they had a serum creatinine requested by their treating doctor. Linkage to the Australia and New Zealand Dialysis and Transplant Registry (ANZDATA), Tasmanian public hospital admitted patient dataset, Tasmanian public hospital emergency presentation dataset, Tasmanian cancer registry and the Tasmanian death registry was performed by the Tasmanian Data Linkage Unit. These linked datasets were specifically chosen to allow us to identify and follow longitudinally an individual with CKD (via the pathology dataset), examine their health service use (emergency presentations and admitted patient datasets), development of additional comorbidities (admitted patient dataset and cancer registry) and outcomes of kidney replacement therapy (ANZDATA) or death (death registry).

Representativeness of the dataset

The estimated Tasmanian resident population (ERP) in 2017 was 522,410 of which 409,729 were aged 18 years and older [8]. Individuals identified within the dataset comprised 47.6% of the overall adult Tasmanian population when studied over one year, 74.2% over three years and 86.8% over five years in the period 2013 to 2017 [10]. As this is a pathology dataset based on serum creatinine, annual representation varied with age: for instance, in 2017, 82.5% of Tasmanian 80 to 84-year-olds were represented, but only 7.8% of people under 18 years. Ethnicity was recorded, but not considered in the analysis.

Data

Data is reported by count (actual number of individuals with CKD), crude rate (number or percentage of people with CKD per 10,000 estimated resident population (ERP) per calendar year), age-specific rate (where numerator and denominator

relate to the same age group) and age-standardised rate (using direct age-standardisation method by comparing to the Australian ERP) [8].

Geocoding of individual addresses was used to link to the Geocoded National Address File (G-NAF), then allocated to statistical area as per Australian Statistical Geography Standard [9]. For this study we used statistical area 4 (SA4). In Tasmania there are four SA4 areas: Hobart (2017 estimated [8] total resident adult (age 18 years and older) population 178,887), South East (30,415), Launceston and North East (113,231), West and North West (87,195). For the purposes of this study we combined Hobart and South East, so that all analyses are by the remaining 3 areas corresponding to major hospitals/health services.

Diagnosis of CKD

Chronic kidney disease in individuals 18 years and older was defined using Kidney Disease Improving Global Outcomes (KDIGO) criteria [11] (with $eGFR_{creat}$ calculated using the 2009 CKD Epidemiology Collaboration (CKD-EPI) creatinine equation (CKD-EPIeGFR) [12]), This required two reports of abnormal kidney function (eGFR $<$60 mL/min per 1.73 m^2) at least 3 months apart or, in those with eGFR $\geq$60 mL/min per 1.73 m^2, a urinary albumin-creatinine ratio (uACR) $\geq$2.6 mg/mmol in males) or $\geq$3.5 mg/mmol in females. CKD severity was classified according to the KDIGO CKD staging system using both the eGFR and uACR measures. For this, we considered stages G1–G5 for eGFR and A1–A3 for uACR categories [11]. Tasmanian laboratories use enzymatic assays for measurement of creatinine, immunoassay for urinary albumin and all results are isotope dilution mass-spectrometry (IDMS)-aligned as previously reported [13].

Definition of incidence

Within the study period, the first-time a patient met the KDIGO CKD criteria within our pathology dataset or had a start date in the ANZDATA dataset (indicating commencement of KRT), they were defined as having CKD.

Definition of prevalence

If a patient had started in the ANZDATA dataset prior to our study period, they were categorised as 'prevalent' CKD in 2004 (start of study period). A patient remained a prevalent case until we had a confirmation of death from any of our datasets (death, AP, cancer, ANZDATA). To minimise bias, we censored observations at 18 months from last eGFR measurement, if no further eGFR measurements were made.

To enable comparisons with previous publications, including the Australian Health Survey [3] and the Australian Diabetes, Obesity and Lifestyle study (AUSDIAB) which did not use the standard Kidney Disease Outcomes Quality Initiative (KDOQI) definitions, we also considered a single-test definition of CKD where eGFR $<$60 mL/min/1.73 m^2 or uACR was recorded on the first test in any one calendar year. A single test cannot exclude short-term variation, likely due to intercurrent illness (rather than true chronic kidney disease).

The CKD.TASlink protocol was reviewed and approved by the Tasmanian Human Research Ethics Committee (Approved study H0016499).

Results

During the 14-year study period, 460,737 Tasmanian adults had a serum creatinine measured. The CKD Cohort was detected as 56,438 which consisted of those detected by pathology met the international definition of CKD (56,039) or presence on the ANZDATA registry (399) [10]. There were 1051 individuals treated with KRT over the 14-year period, many subsequent to diagnosis.

Incidence

The age-standardised annual incidence has plateaued over the last decade to around 99 per 10,000 Tasmanians or 1% of the adult population (Table 1).

Up to 6,264 Tasmanians developed CKD for the first time each year during the study period. CKD was rarely seen in the 18–54 year-old age group with an incidence of just 8 per 10,000 in 2017, but higher in the 55–74 year-old age group at 137 per 10,000, and up to 677 per 10,000 for those aged 75 years and older (Figure 1).

There are consistent geographic differences in the age-standardised annual incidence of chronic kidney disease. In 2017, Launceston and North-East region had a 12% higher (98 per 10,000 age-standardised population) and West and North-West region had a 45% higher incidence (128 per 10,000) compared with Hobart and South-East (87 per 10,000) Tasmania (Supplementary Table 1). Whilst there has been an overall reduction in incidence during the study period, incidence in the West and North-West region remains high.

Women were consistently more likely to develop CKD than men (Supplementary Table 2). The age-standardised annual incidence has reduced in the last 10 years to around 105 per 10,000 Tasmanian women or 91 per 10,000 Tasmanian men.

Prevalence

The overall prevalence of CKD in Tasmania (using two measures of eGFR at least 90 days apart) increased nearly 50% between 2007 to 2017, so in 2017 there were more than 33,000 Tasmanians with CKD. This age-standardised prevalence has somewhat stabilised in the last 5 years at around 650 per 10,000 (6.5%), but is 31% higher in Tasmanian women than Tasmanian men, with age-standardised prevalence of 734 per 10,000 women and 562 per 10,000 men (Figure 2).

Using a single-test definition of CKD to allow comparison with the Australian Health Survey, AUSDIAB study and other single-measure reports, annual prevalence was double that of the two-measure KDOQI definition, consistently around 12–13% (Figure 3).

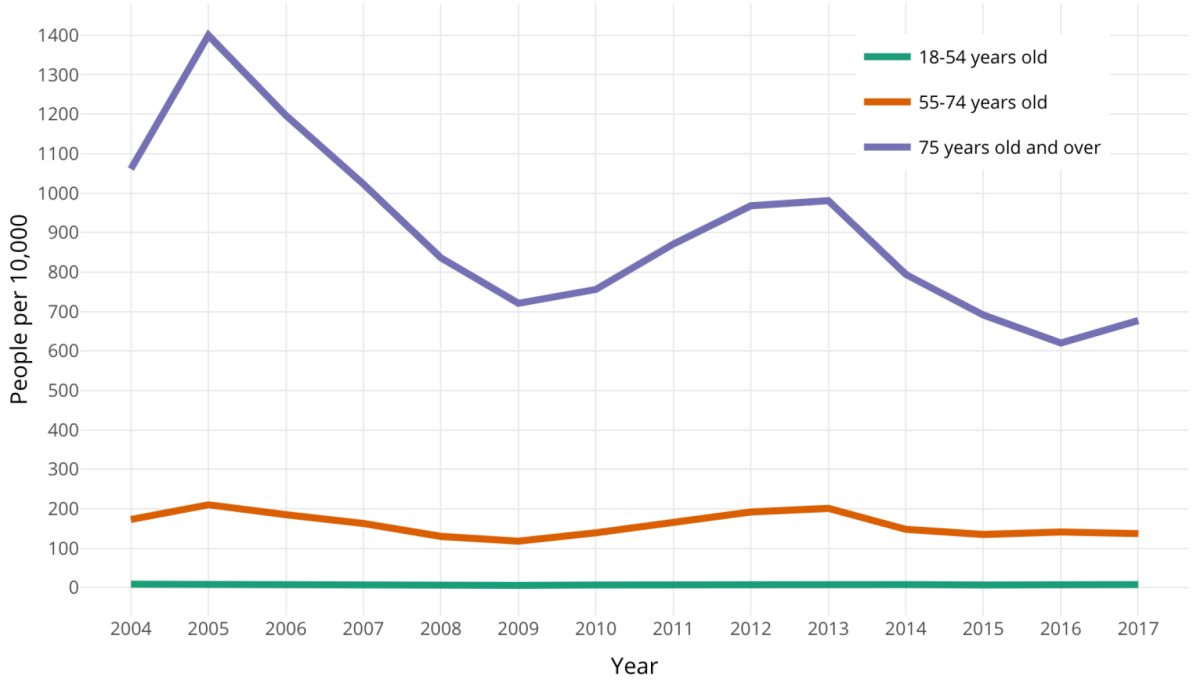
There are clear geographical differences (Supplementary Table 3) in the age-standardised prevalence of CKD with the West and North-West having 18% greater prevalence (724 per 10,000) compared to Hobart and South East Tasmania (616 per 10,000) in 2017. This gap has increased in the last 10 years; in 2008 the relative difference was only 11%.

Table 1: Incidence of CKD in Tasmania by calendar year using KDOQI definitions [4]

Year	ERP (18+)*	Number with CKD	Crude		Age standardised		
			%	per 10,000	%	per 10,000	95% CI
2004	365,315	5218	1.43	143	1.38	138	134.3–141.7
2005	363,771	6264	1.72	172	1.76	176	171.6–180.4
2006	361,388	5025	1.39	139	1.53	153	148.8–157.2
2007	361,190	4204	1.16	116	1.34	134	129.9–138.1
2008	363,186	3322	0.91	91	1.09	109	105.3–112.7
2009	366,960	2944	0.80	80	0.97	97	93.5–100.5
2010	370,616	3286	0.89	89	1.05	105	101.4–108.6
2011	372,643	3876	1.04	104	1.22	122	118.2–125.8
2012	371,975	4381	1.18	118	1.38	138	133.9–142.1
2013	370,730	4515	1.22	122	1.43	143	138.8–147.2
2014	370,478	3494	0.94	94	1.12	112	108.3–115.7
2015	371,571	3164	0.85	85	1.00	100	96.5–103.5
2016	373,213	3149	0.84	84	0.95	95	91.7–98.3
2017	376,941	3314	0.88	88	0.99	99	95.6–102.4

*ERP (18+years) corrected for existing prevalence.
CKD: Chronic kidney disease, KDOQI: Kidney Disease Outcomes Quality Initiative [4], ERP: Estimated resident population, 18+: aged 18 years and older. 95% CI: 95th percentile confidence intervals.

Figure 1: Incidence of CKD in Tasmania according to different age groups



Whilst the increase in the number of Tasmanians with CKD was predominantly seen in the earlier stages G1-G3a, the latter stages (G3b, G4 and G5) show a 39% increase over the last decade from 6,871 in 2007 to 9,560 in 2017 (Figure 4 and Supplementary Table 4).

This data also confirms that among Tasmanians with end-stage kidney failure (eGFR $<15\,mL/min/1.73\,m^2$), 60–70% are treated with KRT in any one year; this has remained consistent over the last 10 years (Supplementary Table 4).

Testing for urinary albumin remains low, with just 28.5% of women and 30.8% of men with stage 3 CKD having both an eGFR and uACR in 2017 (Table 2 and Figure 5). Testing is more likely if resident in the North or North West, as well as for people with comorbid diabetes.

Discussion

Here we report the most comprehensive study of CKD conducted in any Australian state. Taking a whole of population approach, we report the incidence and prevalence of CKD in Tasmania over a 14-year period using community and hospital pathology data. We confirm the slow, steady growth of CKD, predominantly in stages 3a and 3b, but with

Figure 2: Prevalence of (age-standardised) prevalence of CKD by gender

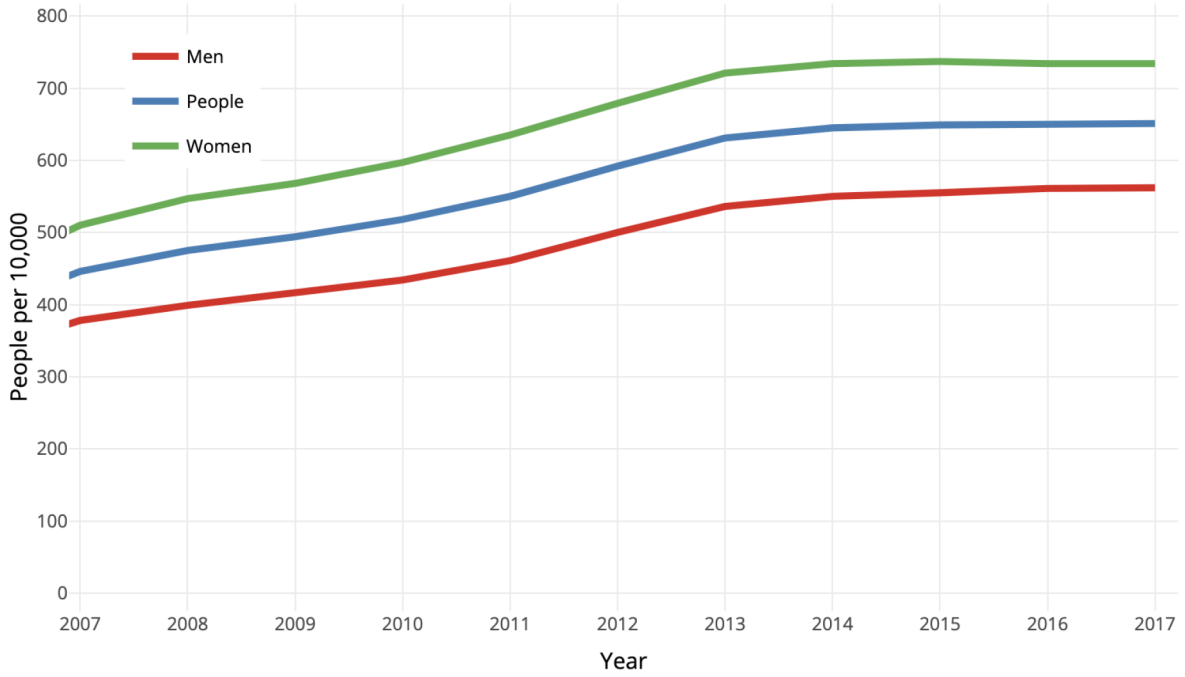
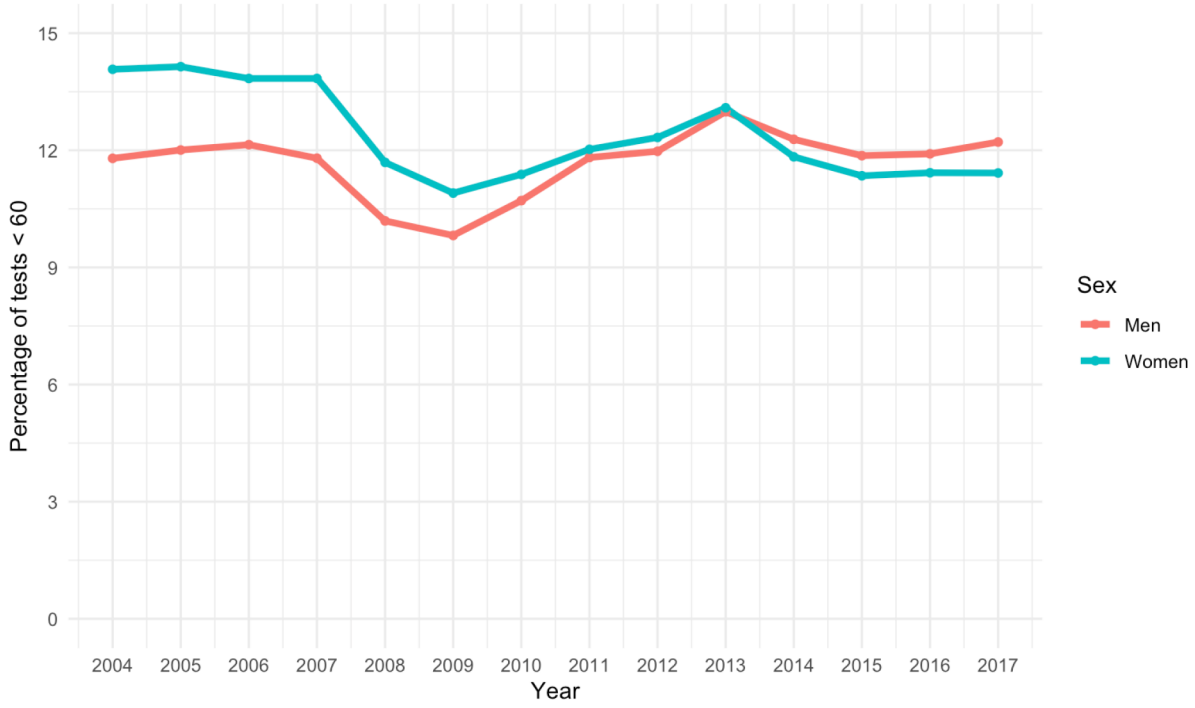


Figure 3: Prevalence of eGFR <60 mL/min/1.73 m^2 in Tasmania using a single measure (first test) in a calendar year

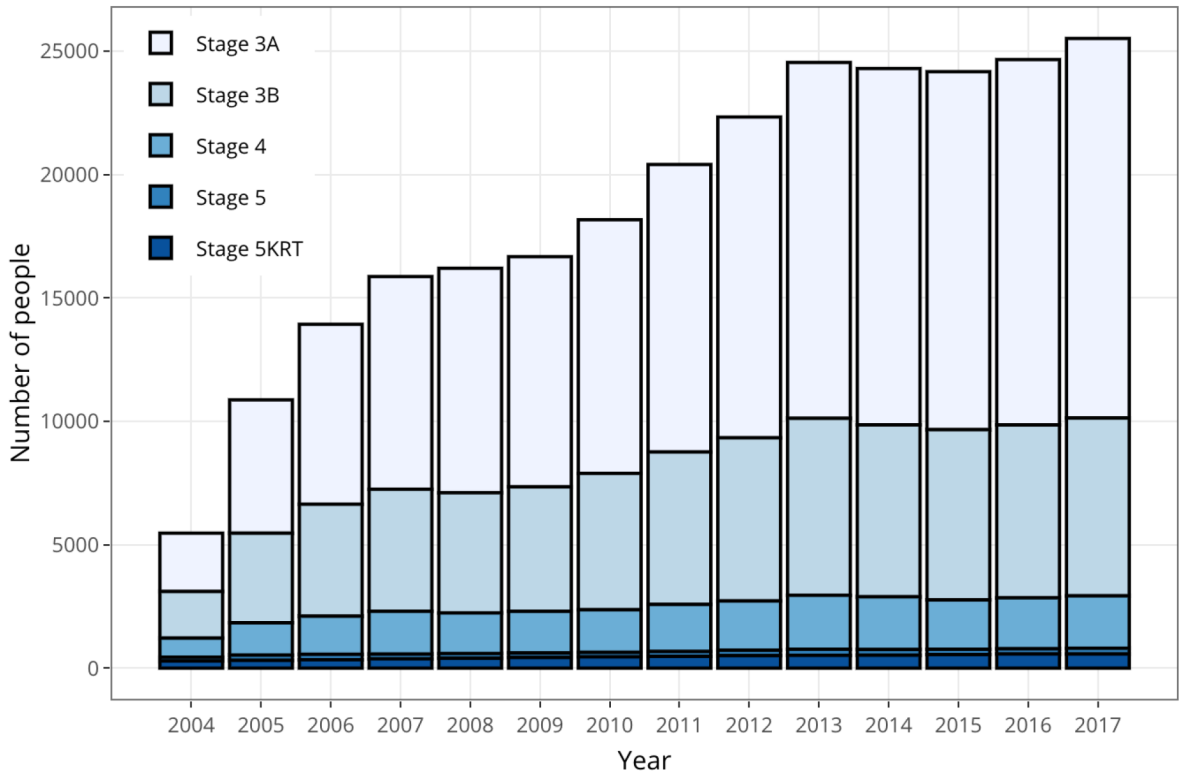


variation by age, gender and geography. Annual incidence is approximately 1.0%, with prevalence at 6.5% using international definitions [11].

The prevalence of CKD in Australia (using a single measure of eGFR) has been previously ascertained [3, 14, 15]. In a 2010 study, White and colleagues tested creatinine once in 11,247 people aged 25 years and over for the AUSDIAB study during 1999–2000 and identified 5.8% had an eGFR <60 mL/min/1.73 m^2 [15]. The Australian Health Survey measured creatinine once in 2011–2012 and reported a prevalence of eGFR <60 mL/min/1.73 m^2 in 3.6% of 17,042 Australian aged 18 years and over [3]. Using data from Australian general practices, we have previously reported a national prevalence of 5.1% using a single measurement of creatinine, and 4.1% when using KDIGO criteria [14]. The more stringent KDOQI two-measurement prevalence of 6.5% and the single-measurement prevalence of 12% confirms the relatively high community burden of CKD in Tasmania.

The increase in prevalence over the 14-year study period is also of interest, with a greater than 50% increase overall and 40% increase in the prevalence of stages G3b, G4 or G5. No previous study has provided this 14-year longitudinal

Figure 4: Prevalence per year by CKD Stage



view of CKD in Australia as the Australian Health Survey biomedical measures taken in 2011 have not been repeated. Our previous work has reported this increase in early CKD [14], but the increasing prevalence in latter stages of CKD is a concern. Once the eGFR drops below 45 mL/min/1.73 m^2 (stage G3b, G4 or G5), morbidity and mortality (especially cardiovascular) increase [16]. These findings highlight the need for early detection and intervention to delay progression to latter stages, with measures that fall well within the domain of general practice (primary) care.

Testing for urinary albumin with a formal uACR through a laboratory remains suboptimal yet is consistent with practice across Australia [17]. Khanam et al., using the Medicine Insight dataset from Australian general Practices reported 19.7% of Australians with stage G3 CKD had a uACR tested in an 18-month period, but this increased to 68.7% if diabetic [17]. It is possible that a dipstick urinalysis is being used for testing for albuminuria or proteinuria, instead of the recommended uACR.

In contrast to previously published data, the majority of people in our study who reached stage 5 CKD in were treated with dialysis or kidney transplants [6, 7]. The Australian Institute of Health and Welfare (AIHW) had reported that 61.3% of Tasmanians who die with CKD are never treated with dialysis or a transplant (increasing to 82% if aged >70years) [7]. This is significantly higher than national figures of 50% and 70% respectively from their study [7]. Our data suggests that only 30–40% of Tasmanians with an eGFR <15 mL/min/1.73 m^2 are not receiving KRT. The difference may be in the methodology used. For our work we censured people 12 months prior to death, whereas AIHW used coding from death certificates, so it is possible a number of people

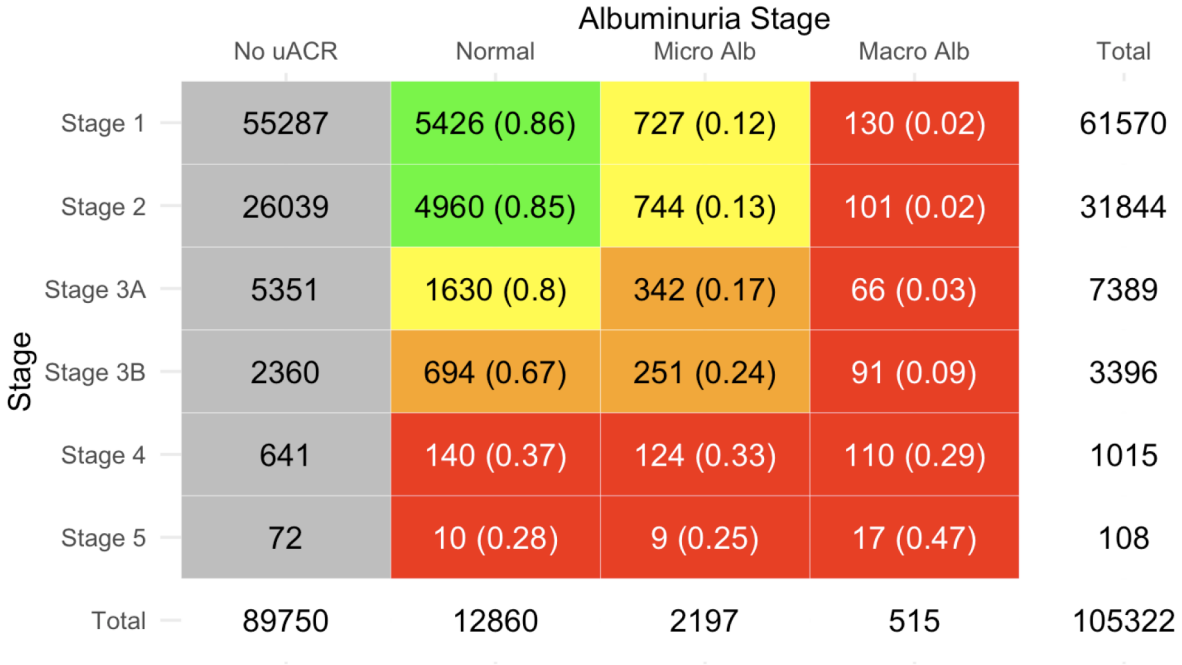
Table 2: Percentage of Tasmanians having both Urine-ACR and eGFR tested in a single year (2017)

	Overall	Hobart and South East	Launceston and North East	West and North West	<75 years	<75 years+DM	<75 years+HT	<75 years+DM+HT
eGFR >60 mL/min/1.73m^2 (Stage 1 & 2 CKD)								
People	14.94	12.03	21.34	14.69	14.22	59.03	28.12	55.22
Women	12.94	10.33	18.20	13.25	12.10	58.05	26.93	55.82
Men	17.33	14.07	25.09	16.43	16.74	59.78	29.00	54.79
eGFR 30–60 mL/min/1.73 m^2 (Stage 3 CKD)								
People	29.59	24.57	36.50	30.74	35.92	61.96	40.44	56.58
Women	28.50	23.16	35.01	30.57	34.92	61.43	38.08	55.03
Men	30.80	26.14	38.20	30.93	36.93	62.39	42.32	57.73

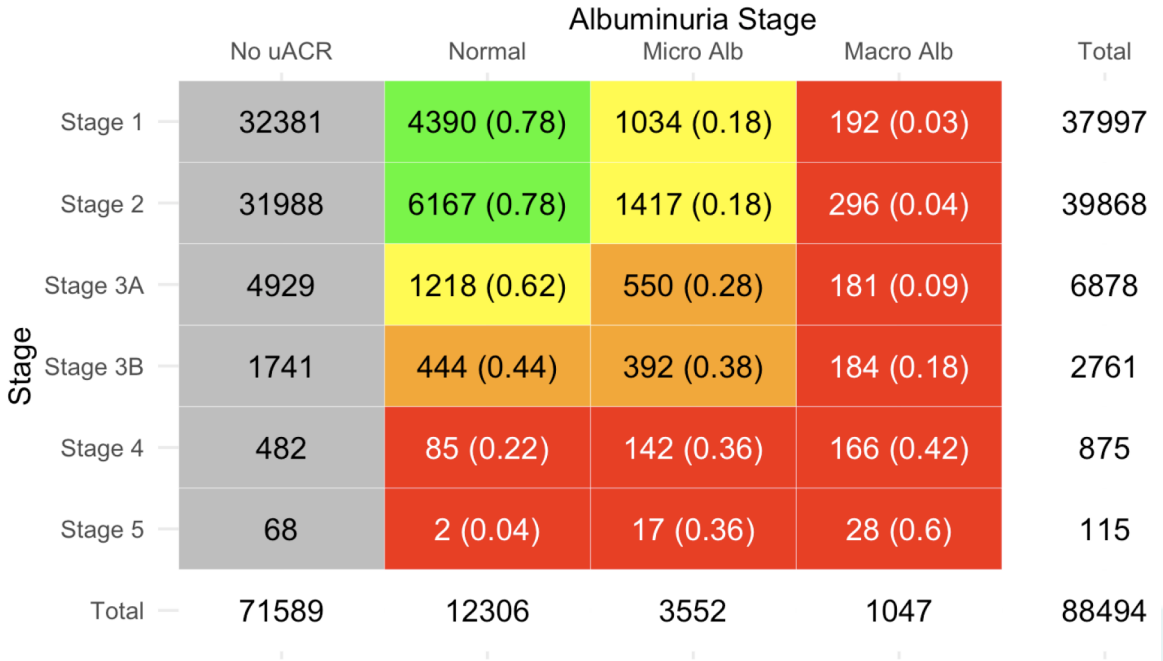
Urine-ACR: Urine Albumin:Creatinine Ratio, eGFR: estimated Glomerular filtration rate. DM: Diabetes Mellitus, HT: Hypertension.

Figure 5: KDOQI prevalence [11] of CKD in Women and Men using first eGFR and uACR measurement in the 2017

a) Women – n (row proportion with uACR)



b) Men – n (row proportion with uACR)



CKD: Chronic kidney disease, KDOQI: Kidney Disease Outcomes Quality Initiative [4], Urine-ACR: Urine Albumin:Creatinine Ratio, eGFR: estimated Glomerular filtration rate, KRT: Kidney replacement Therapy (dialysis or transplantation).

have a decline in function in that last 12 months prior to death.

The striking geographic differences in incidence and prevalence is consistent with previous data on chronic disease in regional and remote Australia. Whilst the whole of Tasmania is classified as regional or remote, parts of the North West region of Tasmania are classified as remote or very remote by the Australian Statistical Geography Standard [9]. Compared with major cities, rural Australians are treated with dialysis or transplants less frequently (with incidence rate ratios of 0.85 for inner regional and 0.81 for outer regional) and have a higher mortality rate (HR 1.08 for inner regional and 1.19 for outer

regional) [18]. Australians living in 'rural and remote' areas consistently report a greater number of health risk factors, lower levels of education and income, less access to health services and subsequently poorer health outcomes [19]. These differences are seen in Tasmania, with the people resident in the West and North-West of Tasmania having the highest number of risk factors for chronic disease [20, 21], the highest incidence and prevalence of CKD as well as the greatest growth in CKD prevalence over the last decade.

A gender difference in CKD incidence and prevalence is well known [22] and identified in our results. Tasmanian women had up to 15% higher incidence and 30% higher prevalence of CKD than Tasmanian men. These differences were consistent over time and by geographic region. What we have not yet defined is the progression of CKD in an individual (and whether men progress faster) to an outcome of KRT or death. Both of these factors will be vital to understand the natural history of CKD in the Tasmanian community as men currently make up >60% of all Tasmanians on KRT [5].

The strengths of this study include the whole of population approach, the longitudinal 14-year study-period and the use of both community and hospital-based laboratory data for diagnosis of CKD. There are limitations however, many of which are due to the retrospective, linked-data approach. The datasets used primarily exist for other purposes and therefore do not have the granular detail that a kidney-specific dataset might have. Whilst we did include the major laboratory providers, some smaller providers were not included, so it is possible that a small number of Tasmanians are not included.

Conclusion

This study confirms the high and increasing community prevalence of CKD, especially in stage 3 CKD in the state of Tasmania. There are significant geographic and gender variations, especially when it comes to use of KRT, but it is reassuring to see that the majority of people with end-stage kidney failure are actually receiving KRT, contrary to previous Tasmanian reports. Understanding these geographic and gender variations are important to deliver equitable access to health services for the entire population of this island state of Australia.

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Some of the data reported here have been supplied by the Australia and New Zealand Dialysis and Transplant Registry. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy or interpretation of the Australia and New Zealand Dialysis and Transplant Registry.

Statement on conflicts of interest

This work was made possible through funding from the Tasmanian Community Fund and the Royal Hobart Hospital Research Foundation.

The authors declare no further conflict of interest in relation to this current manuscript.

Ethics statement

The CKD.TASlink protocol for this study was reviewed and approved by the Tasmanian Human Research Ethics Committee (Approved study H0016499).

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Supplementary table 1: Incidence of chronic kidney disease in Tasmania by geographical region

	Hobart and South East						Launceston and North East						West and North West					
	Crude			Age standardised			Crude			Age standardised			Crude			Age standardised		
Year	ERP (18+)*	No. with CKD	per 10,000	%	per 10,000	95% CI	ERP (18+)*	No. with CKD	per 10,000	%	per 10,000	95% CI	ERP (18+)*	No. with CKD	per 10,000	%	per 10,000	95% CI
2004	179620	2827	157	1.52	152	146.4–157.6	103963	991	95	0.93	93	87.2–98.8	81732	1400	171	1.62	162	153.5–170.5
2005	178979	3303	185	1.93	193	186.4–199.6	104029	1262	121	1.23	123	116.2–129.8	80762	1699	210	2.1	210	200–220
2006	177962	2418	136	1.54	154	147.9–160.1	103448	1305	126	1.35	135	127.7–142.3	79978	1302	163	1.76	176	166.4–185.6
2007	178032	1870	105	1.24	124	118.4–129.6	103377	1348	130	1.46	146	138.2–153.8	79781	986	124	1.41	141	132.2–149.8
2008	179719	1610	90	1.09	109	103.7–114.3	103218	1001	97	1.12	112	105.1–118.9	80248	711	89	1.04	104	96.4–111.6
2009	182099	1542	85	1.04	104	98.8–109.2	103733	797	77	0.91	91	84.7–97.3	81128	605	75	0.88	88	81–95
2010	184469	1649	89	1.09	109	103.7–114.3	104441	919	88	1.03	103	96.3–109.7	81706	718	88	1	100	92.7–107.3
2011	185964	1910	103	1.25	125	119.4–130.6	104864	1094	104	1.2	120	112.9–127.1	81815	872	107	1.21	121	113–129
2012	186477	2305	124	1.49	149	142.9–155.1	104293	1089	104	1.22	122	114.8–129.2	81206	987	122	1.35	135	126.6–143.4
2013	186511	2417	130	1.56	156	149.8–162.2	103783	1141	110	1.27	127	119.6–134.4	80435	957	119	1.34	134	125.5–142.5
2014	187200	1548	83	1.02	102	96.9–107.1	103419	1055	102	1.16	116	109–123	79858	891	112	1.29	129	120.5–137.5
2015	188849	1404	74	0.89	89	84.3–93.7	103293	892	86	0.99	99	92.5–105.5	79428	868	109	1.25	125	116.7–133.3
2016	190771	1338	70	0.82	82	77.6–86.4	103424	835	81	0.91	91	84.8–97.2	79017	976	124	1.32	132	123.7–140.3
2017	193635	1487	77	0.87	87	82.6–91.4	104259	914	88	0.98	98	91.6–104.4	79046	913	116	1.28	128	119.7–136.3

CKD: Chronic kidney disease, ERP: Estimated resident population, 18+: aged 18 years and older.

Supplementary table 2: Incidence of chronic kidney disease in Tasmania by gender

	Women							Men						
	Crude			Age standardised				Crude				Age standardised		
Year	ERP (18+)*	Number with CKD	%	per 10,000	%	per 10,000	95% CI	ERP (18+)*	Number with CKD	%	per 10,000	%	per 10,000	95% CI
2004	187674	2911	1.55	155	1.51	151	145.5–156.5	177641	2307	1.3	130	1.24	124	118.9–129.1
2005	186612	3662	1.96	196	2.03	203	196.4–209.6	177159	2602	1.47	147	1.49	149	143.3–154.7
2006	184995	2881	1.56	156	1.74	174	167.6–180.4	176393	2144	1.22	122	1.32	132	126.4–137.6
2007	184129	2369	1.29	129	1.51	151	144.9–157.1	177061	1835	1.04	104	1.16	116	110.7–121.3
2008	184478	1823	0.99	99	1.22	122	116.4–127.6	178708	1499	0.84	84	0.95	95	90.2–99.8
2009	185822	1551	0.83	83	1.05	105	99.8–110.2	181139	1393	0.77	77	0.87	87	82.4–91.6
2010	187228	1774	0.95	95	1.17	117	111.6–122.4	183388	1512	0.82	82	0.92	92	87.4–96.6
2011	187836	2049	1.09	109	1.35	135	129.2–140.8	184807	1827	0.99	99	1.09	109	104–114
2012	187552	2275	1.21	121	1.5	150	143.8–156.2	184423	2106	1.14	114	1.24	124	118.7–129.3
2013	187134	2373	1.27	127	1.58	158	151.6–164.4	183596	2142	1.17	117	1.26	126	120.7–131.3
2014	187302	1767	0.94	94	1.19	119	113.5–124.5	183176	1727	0.94	94	1.03	103	98.1–107.9
2015	188248	1617	0.86	86	1.06	106	100.8–111.2	183323	1547	0.84	84	0.91	91	86.5–95.5
2016	189496	1580	0.83	83	1.01	101	96–106	183717	1569	0.85	85	0.88	88	83.6–92.4
2017	191509	1663	0.87	87	1.05	105	100–110	185432	1651	0.89	89	0.91	91	86.6–95.4

CKD: Chronic kidney disease, ERP: Estimated resident population, 18+: aged 18 years and older.

Supplementary table 3: Prevalence of chronic kidney disease in Tasmania by geographical region

	Hobart and South East						Launceston and North East						West and North West					
	Crude			Age standardised			Crude			Age standardised			Crude			Age standardised		
Year	ERP (18+)*	No. with CKD	per 10,000	%	per 10,000	95% CI	ERP (18+)*	No. with CKD	per 10,000	%	per 10,000	95% CI	ERP (18+)*	No. with CKD	per 10,000	%	per 10,000	95% CI
2004	179769	2976	166	1.61	161	155.2–166.8	104030	1058	102	1	100	94–106	81798	1466	179	1.7	170	161.3–178.7
2005	181955	6015	331	3.18	318	310–326	105087	2263	215	2.08	208	199.4–216.6	82228	3041	370	3.43	343	330.8–355.2
2006	183977	7840	426	4.04	404	395.1–412.9	105711	3371	319	3.06	306	295.7–316.3	83019	4111	495	4.49	449	435.3–462.7
2007	185872	8926	480	4.47	447	437.7–456.3	106748	4458	418	3.96	396	384.4–407.6	83892	4747	566	5.04	504	489.7–518.3
2008	188645	9640	511	4.73	473	463.6–482.4	107676	5083	472	4.39	439	426.9–451.1	84995	5056	595	5.23	523	508.6–537.4
2009	191739	10310	538	4.94	494	484.5–503.5	108816	5504	506	4.65	465	452.7–477.3	86184	5236	608	5.29	529	514.7–543.3
2010	194779	11058	568	5.17	517	507.4–526.6	109945	6012	547	4.96	496	483.5–508.5	86942	5515	634	5.45	545	530.6–559.4
2011	197022	11984	608	5.48	548	538.2–557.8	110876	6679	602	5.35	535	522.2–547.8	87330	5954	682	5.74	574	559.4–588.6
2012	198461	13326	671	5.93	593	582.9–603.1	110972	7260	654	5.71	571	557.9–584.1	87160	6491	745	6.13	613	598.1–627.9
2013	199837	14628	732	6.35	635	624.7–645.3	111043	7881	710	6.06	606	592.6–619.4	86926	7000	805	6.51	651	635.7–666.3
2014	201828	15139	750	6.37	637	626.9–647.1	111300	8414	756	6.33	633	619.5–646.5	86858	7388	851	6.73	673	657.7–688.3
2015	203988	15450	757	6.31	631	621.1–640.9	111707	8753	784	6.44	644	630.5–657.5	86816	7751	893	6.94	694	678.5–709.5
2016	206221	15667	760	6.22	622	612.3–631.7	112177	8972	800	6.49	649	635.6–662.4	86768	8149	939	7.13	713	697.5–728.5
2017	209302	16047	767	6.16	616	606.5–625.5	113231	9319	823	6.51	651	637.8–664.2	87195	8490	974	7.24	724	708.6–739.4

CKD: Chronic kidney disease, ERP: Estimated resident population, 18+: aged 18 years and older.

Supplementary table 4: CKD stages in each year

Stage determined by first eGFR of the year (or previous year(s))						
Year	**Total**	**Stage 3A**	**Stage 3B**	**Stage 4**	**Stage 5**	**Stage 5KRT**
2004	5,470	2,364 (43.2%)	1,890 (34.6%)	771 (14.1%)	156 (2.9%)	289 (5.3%)
2005	10,871	5,403 (49.7%)	3,632 (33.4%)	1,309 (12.0%)	212 (2.0%)	315 (2.9%)
2006	13,932	7,290 (52.3%)	4,537 (32.6%)	1,545 (11.1%)	219 (1.6%)	341 (2.4%)
2007	15,866	8,617 (54.3%)	4,946 (31.2%)	1,736 (10.9%)	189 (1.2%)	378 (2.4%)
2008	16,202	9,095 (56.1%)	4,869 (30.1%)	1,646 (10.2%)	192 (1.2%)	400 (2.5%)
2009	16,671	9,327 (55.9%)	5,042 (30.2%)	1,689 (10.1%)	181 (1.1%)	432 (2.6%)
2010	18,168	10,276 (56.6%)	5,527 (30.4%)	1,728 (9.5%)	180 (1.0%)	457 (2.5%)
2011	20,406	11,648 (57.1%)	6,176 (30.3%)	1,908 (9.4%)	198 (1.0%)	476 (2.3%)
2012	22,330	12,998 (58.2%)	6,611 (29.6%)	1,996 (8.9%)	218 (1.0%)	507 (2.3%)
2013	24,541	14,419 (58.8%)	7,169 (29.2%)	2,187 (8.9%)	246 (1.0%)	520 (2.1%)
2014	24,295	14,440 (59.4%)	6,965 (28.7%)	2,136 (8.8%)	229 (0.9%)	525 (2.2%)
2015	24,167	14,505 (60.0%)	6,899 (28.5%)	1,998 (8.3%)	216 (0.9%)	549 (2.3%)
2016	24,657	14,805 (60.0%)	7,002 (28.4%)	2,067 (8.4%)	210 (0.9%)	573 (2.3%)
2017	25,513	15,381 (60.3%)	7,204 (28.2%)	2,122 (8.3%)	234 (0.9%)	572 (2.2%)

CKD: Chronic kidney disease, eGFR: estimated glomerular filtration rate, KRT: Kidney replacement therapy (dialysis or transplantation).