Comparative Analysis of Chronic Kidney Disease Management and Digital Health Across Australia

CKD Consortium Final Report 2025

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Executive Summary

Background

Chronic kidney disease (CKD), and associated conditions like diabetes and cardiovascular disease, have significant impacts on mortality, morbidity, wellbeing and health system costs. To detect CKD early and prevent progression, at the population level, it is imperative to examine ways to improve the identification and management of early-to-moderate CKD within primary care. In a three-year project supported by the Commonwealth of Australia Department of Health and Aged Care (2021–24), the CKD Consortium brought together partners in three jurisdictions – Menzies School of Health Research, Northern Territory (NT); Western Health, Melbourne, Victoria; and the University of Tasmania, Tasmania – to evaluate progress in the identification and management of CKD in primary care. The study used data from three different digital systems in these jurisdictions, employing a mixed-methods approach combining quantitative analysis of patient data and qualitative interviews with stakeholders. Key findings explore temporal trends in CKD screening and management, comparing them to national guidelines, and identify barriers and enablers to implementing clinical decision support (CDS) systems. The report also examines the cost-effectiveness of such systems and offers recommendations for improving CKD care.

Findings

Significant variations in CKD prevalence, screening rates, and management practices were observed across the three regions. All datasets report more females than males in at-risk groups, but the Tasmanian dataset is the only one to report more males with CKD. TKC has a markedly younger cohort with more than 70% below the age of 55 years. This is likely to reflect the NT cohort in TKC, which is made up largely of First Nations people, primarily from remote and very remote areas. The older age groups in the Western Melbourne and Tasmanian datasets are reflective of the broader Australian population burden of CKD.

Overall, the analysis highlights persistent evidence-practice gaps in the screening of people at high-risk for CKD. The TKC dataset demonstrated the highest rates of *intent to screen* with 52-65% of individuals receiving both eGFR and uACR annually and is likely due to both the high-risk patient cohort of TKC and the adult health assessment MBS incentive. The Western Melbourne data set reflected higher rates of targeted screening in 2017 (approximately 40%) than in the earlier or later years of the study. This pattern, repeated throughout the analysis, is possibly due to incomplete data when outside the period from 2017 to 2019 of the implementation trial from which the Western Melbourne data was sourced. Targeted screening was higher for patients with specific comorbidities such as diabetes and hypertension but still reflected the same pattern. Screening of at-risk people in the Tasmanian dataset was the lowest, at approximately 25% and likely to reflect the lack of primary health data. All three datasets demonstrated challenges in attaining recommended target levels for screening in people with diabetes, with results consistently sitting around 50%.

While this study provides indicative findings regarding the need to improve screening and management of CKD, there are some important caveats around data collection and analysis. Comparisons between the jurisdictional datasets are problematic given the different derivations and purposes of each dataset. Additionally, the study highlights the challenges associated with working with pre-existing health datasets, and also the need for more consistent data coding and collection practices.

The TKC dataset appears to demonstrate high levels of screening and monitoring particularly in the early years, but this is likely due to selection bias of the TKC cohort. The Western Melbourne dataset frequently displayed a pattern of sharp improvements in 2017 and then a downward trend to the end of the study. This is likely due to how the data was collected with data extracted at timepoints between 2017 and 2019 with only historical data for patients prior to April 2017, resulting in a subset of patients attending the practices prior to 2017 contributing to this data. Additionally, practices involved in the implementation trial (which sought to improve the diagnosis of CKD) from which the Western Melbourne data was obtained, had increased numbers of patients diagnosed with CKD in 2018 and 2019, resulting in a shifting denominator with a proportion of those tested in 2017 going on to be diagnosed with CKD. The Tasmanian dataset does not include primary health care episodes of care (apart from some pathology data) and, therefore, focusses on people admitted to hospital. The CKD Consortium study highlights that data quality, linkage and integration across primary and tertiary care remain key challenges to both the provision of CDS and mapping and reporting of the burden of chronic conditions.

Additionally, this report examines barriers and enablers to the implementation of digital CDS tools based on interviews conducted across the three jurisdictions with primary and tertiary-based clinicians, policymakers and researchers. In the NT, Western Melbourne and Tasmania, the respective CDS projects were seen as opportunities for establishing quality improvement processes that support evidence-based care and capture the prevalence of chronic conditions amongst different demographics. The interviews emphasised that making CDS systems attractive and user-friendly and reducing data entry requirements can facilitate uptake. Further, this study highlights the multifaceted nature of chronic condition management and the need for intelligent systems to offer complex clinical decision advice to support patient-centric care. Implementing such CDS systems requires ongoing training and support to ensure continued use, uptake and sustainability.

A cost-effectiveness analysis of CDS was undertaken. It indicates that early diagnosis with appropriate evidence-based management is necessary to improve outcomes and decrease overall cost, which is far more effective than early diagnosis or improved management alone. The findings of this study support calls for investment in CDS tools and partnerships to improve CKD outcomes, reduce the burden of CKD on patients and healthcare systems.

Further, the study clearly demonstrates the need for data linkage and integration, both within and across the health sector, (primary/ community and hospital-based care) to accurately understand disease burdens and trends and to monitor the uptake of evidence-based guidelines. Data linkage is crucial to providing relevant CDS to primary care and to informing resource allocation and service planning.

Policy Implications

These findings have important implications for healthcare policy and practice, highlighting the need to develop targeted strategies to improve CKD prevention and management and the implementation of digital health systems across Australia.

1) **Need for Tailored Strategies**: The variations in CKD identification and management across the Northern Territory (NT), Western Melbourne (Victoria), and Tasmania highlight the need for tailored strategies that consider local contexts, available data, and specific population needs.
2) **Focus on Data Quality and Interoperability**: The study revealed that data quality and coding practices significantly impact the accuracy of population health analysis.
    a) Consistent data collection methods that align with international standards (pathology reporting, diagnostic coding etc) across jurisdictions are required to ensure comparability and validity of analysis.
    b) Investment in interoperable digital health systems that can seamlessly share data between primary and tertiary health services is crucial.
3) **Prioritising User-Friendly Digital Health Systems**: User-friendly interfaces, integration with existing workflows, and minimal data entry are key enablers for successful digital health system uptake.
    a) Digital tools that are easy to use and integrate into clinicians' daily routines should be developed and implemented to avoid alert fatigue and clinician burnout.
    b) Funding should be allocated to user-centred design processes in digital health development.
4) **Importance of Clinician Engagement and Support**: Lack of awareness, training, and incentives, alongside resistance to change, are significant barriers to implementing digital health systems.
    a) Training and ongoing support for clinicians is required to facilitate the adoption of new digital systems.
    b) Incentive programs for clinicians to use digital health systems should also be considered.
    c) Champions within clinical settings are needed to promote the uptake of new systems to promote the benefits.
5) **Addressing Systemic Barriers to Evidence-Based Care**: There was a lack of clarity for clinicians on the medicolegal aspects of Medicare billing for activities related to guideline implementation, as well as a lack of access to guidelines. Clinicians require guidance and support to ensure billings and Medicare claims are ethical and appropriate, ensuring maximisation of funds to support preventative activities related to guideline implementation.
    a) Medico-legal aspects of billing related to guideline implementation should be clarified and reimbursement systems reviewed to ensure they do not create barriers to providing evidence-based care.
    b) Incentives for GPs to seek advice and support from tertiary specialists for complex care either on a patient case basis or scenario to reduce the evidence-practice gap and the need for specialist referral should be considered.

6) **Investment in Chronic Disease Management**: The cost-effectiveness analysis highlights the potential benefits of investment in CDS systems to support early diagnosis and management of CKD.
    a) Investment should be made in CDS systems that support both early diagnosis and evidence-based management to improve patient outcomes and reduce the overall burden of CKD on the healthcare system.
    b) It is important that ongoing funding is allocated to the support and maintenance of digital health systems beyond initial implementation phases.
7) **Focus on High-Risk Populations**: The study confirms the need for targeted resourcing and initiatives to address the inequitable burden of CKD affecting First Nations Australians, especially those living in remote areas.
    a) Resources should be targeted towards high-risk populations and areas with limited access to healthcare.
    b) Initiatives should focus on improving early detection and management of CKD in these communities.
8) **Need for Integrated, Multimorbidity Approaches**: There is a pressing need to move beyond single-disease focused interventions and focus on appropriate models of care to address multimorbidity.
    a) CDS systems which address multimorbidity should be developed and implemented, which better reflect patient needs.
    b) Shared care type management where multiple specialists can support each other and primary care GPs, supported by monitoring tools.
    c) Resources should be allocated to the development of condensed and accessible guidelines for clinicians that address the complexity of managing multimorbidity, to ease implementation in practice.
9) **Collaboration and Knowledge Sharing**: Need for collaborative efforts between policymakers, researchers, and clinicians to ensure equitable and effective CKD care for all Australians.
    a) Collaboration and knowledge sharing between stakeholders should be encouraged through targeted funding initiatives.

In summary, the findings underscore the potential of digital health systems to enhance CKD management in Australia but also highlight the necessity of addressing systemic barriers to the implementation and uptake of digital health systems and ensuring equitable access to care. There is a need to focus on improving data quality, promoting user-friendly technology, supporting clinicians to access and use technology and administrative data in ensuring high quality care, and investing in comprehensive, integrated approaches to chronic disease management.

1 Chapter 1 - Overview

1.1 Chronic Kidney Disease burden and impact across jurisdictions

Chronic diseases – in particular, cardiovascular disease, diabetes and kidney disease – account for high mortality and morbidity rates in Australia and internationally (1). Chronic kidney disease (CKD) is increasingly recognised as a major public health issue that leads to significant illness and early death (2). It is often a poorly recognised condition, with burden of disease routinely under-represented in health surveys, although the awareness of the multifaceted burden (prevalence, morbidity, mortality, costs) of CKD is growing (3). CKD is not only a serious stand-alone ailment but also exacerbates risks associated with other conditions. Approximately 1.7 million Australians aged 18 years and over show biomedical indicators of CKD (4). The prevalence of CKD varies by ethnicity and socioeconomic status, with First Nations people and those living in remote and very remote locations experiencing significantly higher rates. Older Australians are also at high risk of CKD. Rates among those aged 75 and over are twice as high as those aged 65–74 and around seven times as high as those aged 18–54 (4).

The 2011–13 Australian Health Survey (AHS) included biomedical markers from 11,000 individuals aged over 18 years across Australia who voluntarily provided blood and/or urine samples, which were tested for a range of chronic diseases, including cardiac disease, diabetes and kidney disease (5). While there have been additional self-reported health surveys since that time adding to the understanding of Australia's health, the AHS is the only study that included biomarkers and has been used to model the burden of reported and unreported kidney disease across Australia.

The Northern Territory (NT) has the heaviest burden of chronic disease in Australia, with chronic conditions accounting for a substantial proportion of health resources and the largest proportion of avoidable hospital admissions (6). Previous studies have highlighted the extent of multimorbidity in the NT – approximately 60% of Territorians over the age of 50 years live with at least two chronic conditions (7). Further, the rate of hospitalisation with CKD in the NT is above three times that of other parts of Australia (4). First Nations people have a higher risk of developing CKD and of disease progression to end stage kidney disease (ESKD) with prevalence rates of ESKD four times that of the Australian population (8).

Victoria has a reported CKD crude prevalence of around 11%, with the Macedon Ranges and Northwestern Melbourne identified as two of the CKD hotspots (9). The prevalence of CKD was reported to be higher in males than females, particularly for males aged 55 and older. The health risk profile of Victorians, for several key indicators, is significantly worse than for all Australians. The rate ratio is higher for several indicators including uncontrolled blood pressure (1.07), heart, stroke and vascular disease (1.08), and obesity (1.02) (10).

In Tasmania, the prevalence of CKD is particularly high in people aged over 75 years (55.8 %) compared to the national 2011–13 average of 44.5%. In addition, the health risk profile is significantly worse across all indicators (blood pressure, obesity, smoking, activity, heart/ stroke/ vascular disease) for Tasmanians compared to other Australians (10).

Chronic conditions such as diabetes, cardiovascular disease and CKD have common risk factors. As such, it is essential to improve the identification and control of these conditions and their shared risk factors. Early recognition and management of these risk factors and chronic conditions provides an opportunity to potentially maintain health and prevent disease progression (11). Primary care, provided through General Practice, Community Health Centres, Aboriginal Community Controlled Health Services (ACCHS), plays a crucial role in early identification and management of chronic conditions.

1.2 CKD Consortium

With the growing economic burden of kidney disease (12), there is an impetus to examine ways to improve the identification and management of early-to-moderate CKD within primary care. In a 3-year project supported by the Commonwealth of Australia Department of Health and Aged Care (2021–24), the CKD Consortium brought together partners in three jurisdictions to evaluate progress in the identification and management of CKD in primary care. The CKD Consortium partners are Menzies School of Health Research, Northern Territory; Western Health, Melbourne, Victoria; and the University of Tasmania, Tasmania. The project used data from three different digital systems and covered diverse populations in the three jurisdictions. The overall aim of the Consortium was to provide an overview of CKD patient care in primary health services by analysing the data from the three specific digital clinical projects – Territory Kidney Care (TKC) in Northern Territory (NT); Chronic Disease Early Detection and Improved Management in Primary Care Project (CD-IMPACT) referred to as Western Melbourne, in Victoria; and linked data from the CKD.TASlink project in Tasmania (Figure 1).

1.3 Consortium Objectives

The objectives of the CKD Consortium were to:

1. Examine temporal trends in primary health care identification and management of CKD, using existing individual- and episode-level data for each jurisdiction;
2. Examine the real-world impact of interventions (including the publication of national primary care guidelines and local initiatives);
3. Evaluate the barriers and enablers to implementation of initiatives that harness the power of existing electronic medical record data, such as decision support and report feedback tools;
4. Study the cost-effectiveness of the implementation of systems of care that incorporate such tools;
5. Implement key findings into practice through existing collaborations; and
6. Disseminate learnings through primary and specialist care networks.

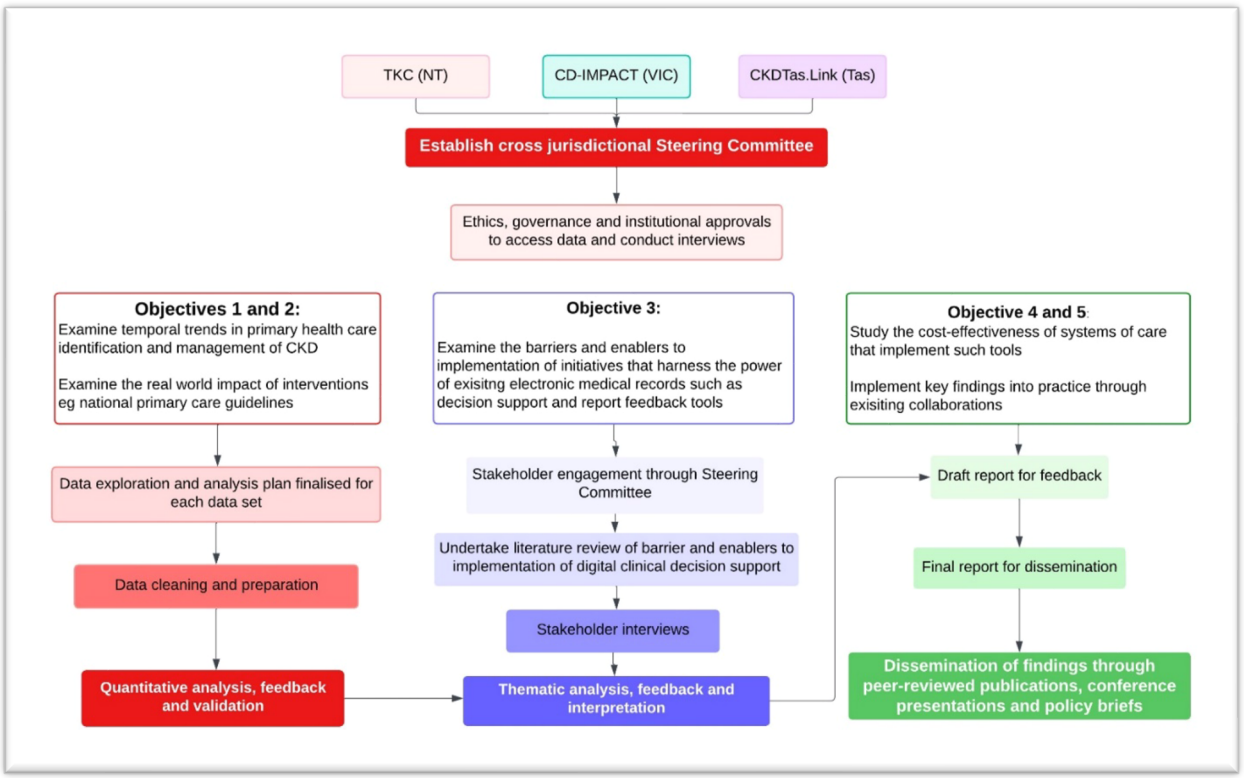

Figure 1: Study design flowchart

1.4 Northern Territory

Menzies School of Health Research (Menzies), in partnership with NT Health, the Aboriginal community-controlled sector and NT Primary Health Network (NTPHN), developed Territory Kidney Care (TKC) – an integrated clinical information system that consolidates health information from government and non-government, primary and tertiary sectors in one place. Participating health services include 6 public hospitals, 56 government primary health services and 12 Aboriginal Community Controlled Health Services (ACCHS) primarily in rural and remote areas. The aim of TKC is to assist primary health clinicians deliver efficient and timely care and close the evidence-practice gap.

TKC utilises a service orientated architecture that connects to 15 existing health platforms, automatically and securely transferring clinical information of select patients based on agreed criteria (13). Eligible patients include those with CKD, receiving kidney replacement therapy (KRT) or with a diagnosed risk factor for CKD such as diabetes, hypertension or cardiovascular disease. Algorithms applied to the consolidated records stratify patients according to risk of CKD and CKD stage, enter patients into surveillance loops and initiate triggers to alert the tertiary clinical support team of actions required (14). TKC went live in 2019 and by 2023, 12 ACCHS health services along with all primary and tertiary government services were participating. Although each health service provided 5 years of historical information for eligible patients, data for the earlier years in this platform may be incomplete.

1.5 Victoria

The Victorian Chronic Disease Early Detection and Improved Management in Primary Care Project (CD-IMPACT) (15) was designed to improve the diagnosis and management of CKD, diabetes, and cardiovascular disease in Western Melbourne. A customised software program was developed with Pen CS © (www.pencs.com.au) that, together with the general practice electronic health record (EHR), could be used for clinical auditing. The tool enabled practices to bring up customised lists of patients not receiving recommended testing or treatment for different conditions. The project focused on adult patients who had, or were at risk of developing, type 2 diabetes, CKD or cardiovascular disease. Nine general practices piloted the CD-IMPACT e-technology program, which also included education, monitoring and support, however one practice was excluded due to a practice merger that affected data quality leaving eight practices in the analysis. The program was delivered as a randomised stepped wedge trial, with a staggered roll out where two to three new GP practices were brought on to the intervention every 16 weeks. Of the included practices (all of which were drawn from low socioeconomic areas), one was from inner metropolitan, 3 from inner regional and 4 from outer metropolitan areas. The CD-IMPACT program ran for 15 months over 2017 and 2018, with an additional 12-month extension examining sustainability of the program.

1.6 Tasmania

In Tasmania, data linkage techniques were used to map the state-wide prevalence of CKD (CKD.TASlink) (16), specifically to identify gender and geographic inequities in screening for CKD, rural and remote access to renal replacement therapy and variation in cardiovascular outcomes. CKD.TASlink involved linking 5 health datasets (including public hospital admissions and emergency presentations, national renal data, cancer and death registries) and 2 pathology datasets (community and hospital). The study population of 460,737 people (representing 87% of the state's adult population) included adults with a creatinine test during the period 1 January 2004 to 31 December 2020; and those with CKD having had 2 measures of eGFR<60mL/min/1.73m^2 at least three-months apart (17). The dataset does not include primary health care episodes of care (e.g. BP, weight, ICPC codes) apart from pathology data mentioned above and, therefore, focusses on people admitted to hospital.

2 Chapter 2 Methodology

KEY POINTS

1. The study applied a mixed methods design that included both analysis of datasets and interviews with key stakeholders from the three jurisdictions.
2. Program datasets from each jurisdiction were analysed to assess trends in targeted screening for early identification and management of CKD, as per national guidelines. CKD management was assessed against the Kidney Health Australia Clinical Action Plans.
3. Comparisons between jurisdictional data sets and with previous analysis were not possible or intended due to differences in data collection methods, differing contents of data sets and scope of project.

2.1 Overview of data sources

The study applied a mixed methods design that included both quantitative analysis of datasets from the three jurisdictions and qualitative interviews with key stakeholders to achieve the stated goals and objectives (see Figure 1). The aim of the Consortium was not to replicate the results of previous work undertaken by the CD-IMPACT and CKD.TASLink projects, but rather to draw from the data contained in the three different projects, and as such, results cannot be compared to these studies. A literature review of uptake of clinical decision support systems, and cost-effectiveness of such systems, provided further understandings of the enablers and barriers to implementation (18, 19).

Governance statement

The study was governed by a Project Working Group (that met monthly or as required by the status of the study), whilst the Project Advisory Committee met on a quarterly basis.

The study was provided with approval by the following bodies:

Jurisdiction	Approval details
North Territory	Ethics approved 7 September 2021 by Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research, HREC: 2021-4081.
Victoria	Ethics approved 28 March 2022 by the Western Health Low Risk Human Research Ethics Panel – Approval to conduct research and site-specific assessment (SSA) authorisation. LREP:HREC/21/WH/78672 – LREP approval date 21 October 2021, SSA approval date 28 March 2022.
Tasmania	Ethics approved 8 October 2021 by the University of Tasmania Human Research Ethics Committee. Project ID: 26387. Approval was also granted by the Tasmania Data Linkage Unit (TDLU), reference TDLU126, dated 30 August 2022.

2.1.1 Quantitative data sources

The TKC dataset is securely stored in the NT Health data warehouse, and data was provided to the Menzies project team and analyst based in Darwin. The Western Melbourne dataset was held by Western Health and analysis occurred remotely on their secure server by the NT statistician. The Tasmanian dataset was held by the University of Tasmania and data analysis also occurred remotely on their server by a Menzies analyst based in Adelaide.

2.1.2 Qualitative data sources and methods

Qualitative data was collected through interviews with key stakeholders, including primary care clinicians (GPs, chronic disease nurses) and managers as well as nephrologists from each jurisdiction. The aim was to explore the participants' experiences in using the digital health tools (and associated outputs), determine the perceived impact on care management (Objective 2 and 3) and service planning, and identify the enablers and barriers to the uptake of decision support tools (Objective 4). Interviews were coded by two researchers to identify emerging themes and reviewed by a third researcher to validate interpretations and findings. Thematic analysis of interviews identified common themes across jurisdictions and professional streams as well as issues specific to each jurisdiction.

2.2 Quantitative data analysis

Program datasets in each jurisdiction were analysed to assess trends in the early identification and management of CKD, as per Kidney Health Australia's (KHA) Chronic Kidney Disease Management in General Practice Guidelines (20).

The data analysis focused on two aspects of Objective 1 using the KHA Guidelines 2015:

i. Assess if *CKD screening* for at-risk populations was consistent with guidelines across the three identified jurisdictions, and

ii. Assess if *CKD care and management* was consistent with guideline recommendations across the three identified jurisdictions.

The analysis of each dataset was conducted separately against key evaluation indicators. Quantitative data from the three jurisdictions was not pooled nor combined for this analysis.

2.2.1 TKC – NT

The TKC dataset is held in NT Health's data warehouse and is comprised of structured data and unstructured data. Structured data includes coded information, such as International Classification of Diseases (ICD) 10AM and International Classification of Primary Care (ICPC) codes. Unstructured data includes observations (blood pressure measurements, height, weight etc), results (biological measurements such as pathology, microbiology, and urinalysis), and medications. Data in TKC is a subset of information held by participating health services for patients who meet the inclusion criteria of at-risk-of-CKD, or diagnosed with CKD, or receiving KRT. Additionally, it may include individuals who only have hospital data, with no primary care episodes of care, as they may have attended a primary health service not participating in TKC at the time of the evaluation. Analysis has therefore centred on individuals with primary health data between 2016 and 2020 (Figure 2).

As of December 2020, there were 67,010 patients in the TKC system. As the CKD Consortium focused on the identification and management of CKD in primary care for adults, patients were excluded if they were less than 18 years of age at entry, were receiving KRT or deceased. Patients without a primary health episode of care (either government or ACCHS) were also excluded. The analysis includes 28,381 alive and active adults with CKD or at risk of CKD as of December 2020. Active is defined as attending a

primary health service in the previous 24-months. At-risk patients were defined as having a coded risk factor for CKD but not CKD. Risk factors included diabetes, obesity, cardiovascular disease and hypertension. See Table 1 for conditions included.

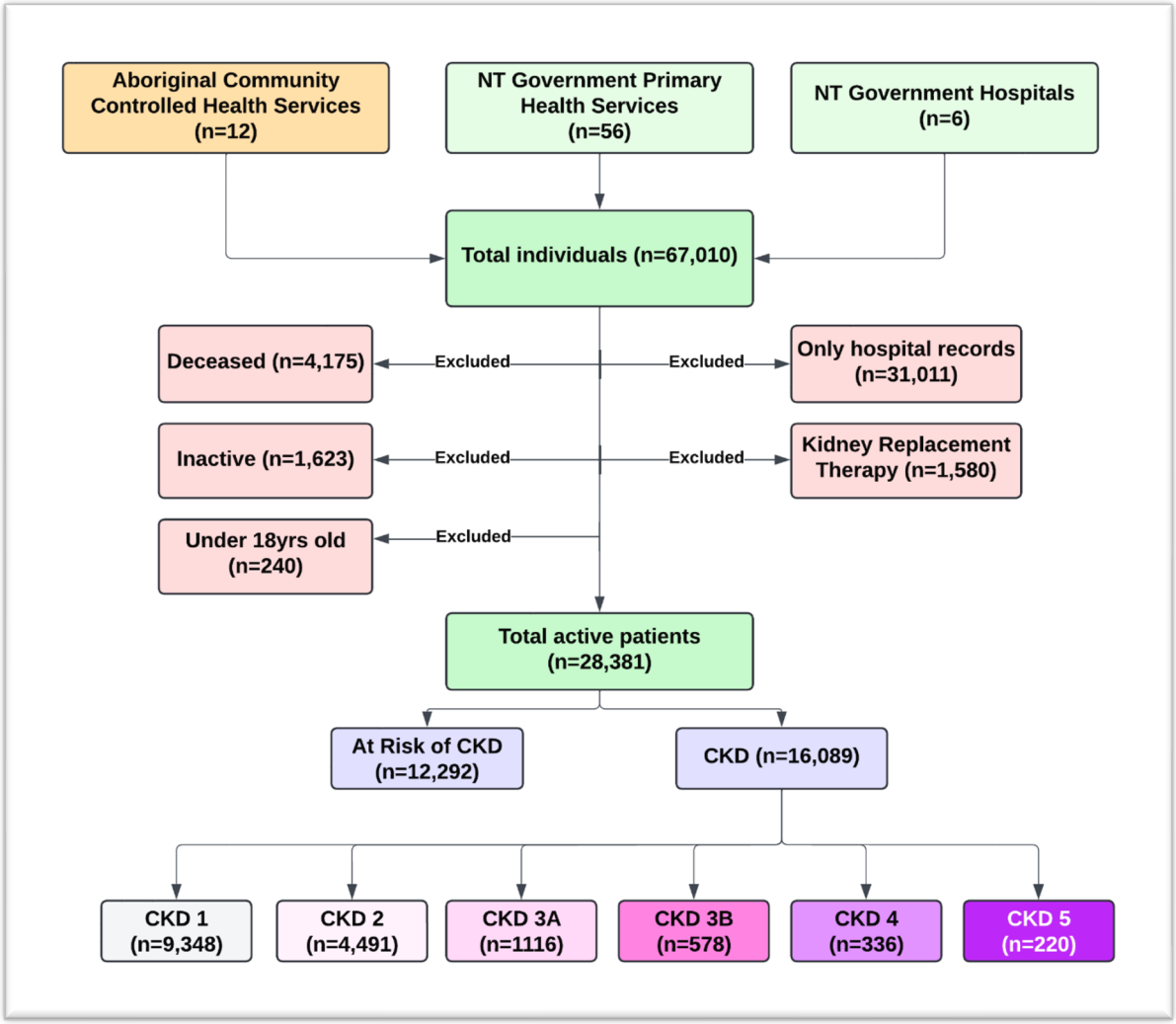

Figure 2: Datasets making up the NT cohort

2.2.2 Western Melbourne - Victoria

Data from 8 GP practices, covering 2015-2019 but focussing on a patient cohort that attended the services in 2017-2019, were included in this analysis. Data was provided to the study team according to financial year as opposed to the other datasets, which were examined according to calendar year. All active patients during 2017 and 2018, defined as having attended their general practice at least three times within the preceding 24 months, and aged ≥18 years, were included. Patients were followed through to 2019. Data included coded (ICPC and medications) data, observations (BP, BMI) and pathology data including fasting and random blood sugar tests. The dataset did not include hospital data. As the data extracts took place between 2017 and 2019, only patients attending the practices at this time had data included in the preceding years. A total of 19,434 active participants was included in this analysis (Figure 3). As with the TKC cohort, at-risk was defined as having a risk factor for CKD but not CKD. See Table 1 for conditions included.

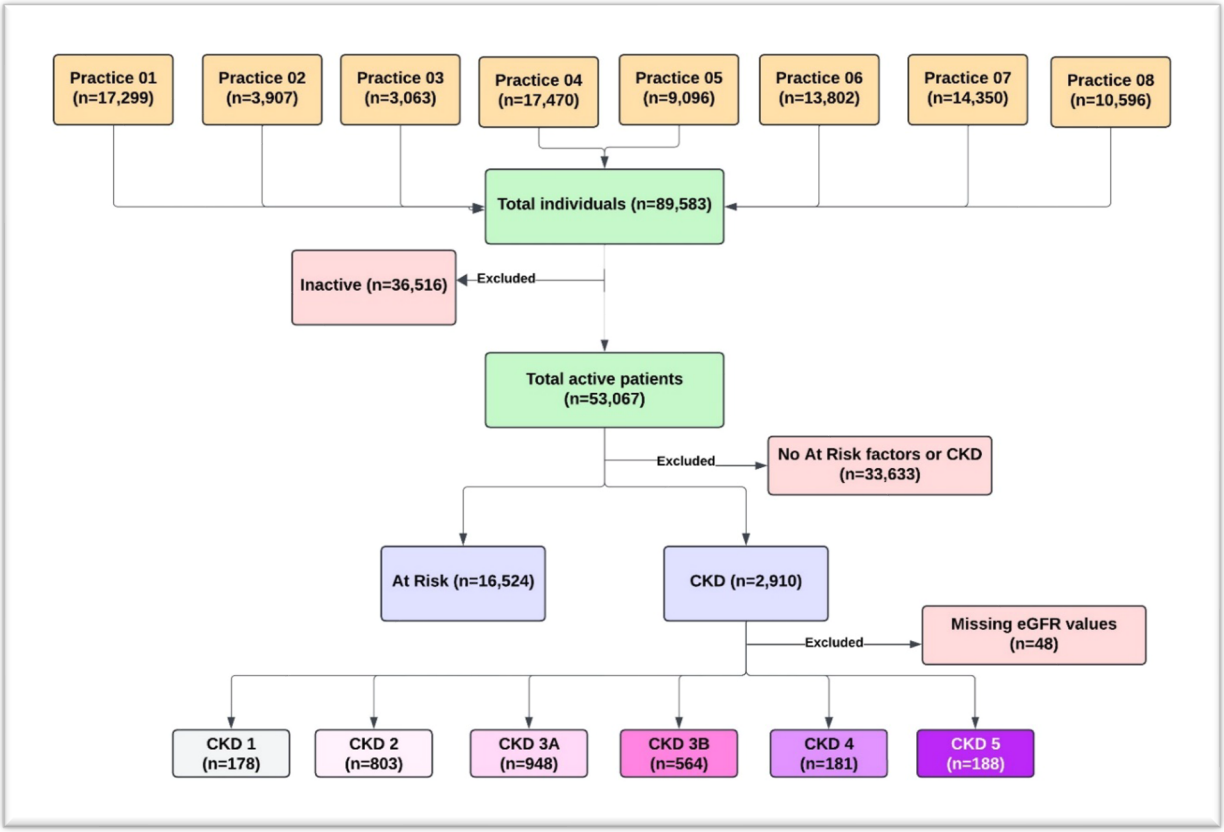

Figure 3: Datasets making up the Western Melbourne cohort

2.2.3 Tasmania

The Tasmanian dataset consisted of a large, linked dataset covering the period from 2004–2020. However, data before 2016 was removed as this study focused on assessing the consistency of screening and management of CKD in relation to more recent clinical practice guidelines. The linked datasets included:

- Community (Hobart, Launceston & North-West Pathology) and Royal Hobart Hospital Pathology datasets.
- Australia and New Zealand Dialysis and Transplant Registry (ANZDATA) – data on all Tasmanians receiving kidney replacement therapy (KRT), i.e., dialysis or kidney transplantation and includes recorded comorbidities.
- Public Hospital Admitted Patient (PHAP) dataset – episode level coded (ICD) data and demographic patient data from all public hospitals in Tasmania.
- Gender data – the gender file is a conglomeration of all the linked data files as not all participants had their gender recorded consistently in all datasets. Thus, gender for an individual was determined based on the recorded majority (75% or more) across all the datasets.
- Tasmanian Death data - which presents both coded underlying and contributing cause of death from the Australian Coordinating Registry.

A Specific Project Linkage Key linked deidentified patient records across datasets. The dataset did not include data from primary health services (other than pathology data) and, therefore, for completion, focused on patients with a hospital admission, excluding individuals without an inpatient episode of care. Further exclusions were applied in the final analysis removing observations of same-day duplicates, non-Tasmanian residents, individuals <18 years and data prior to 2016. Figure 4 shows the merging of all the datasets and selection of the Tasmanian cohort in this analysis.

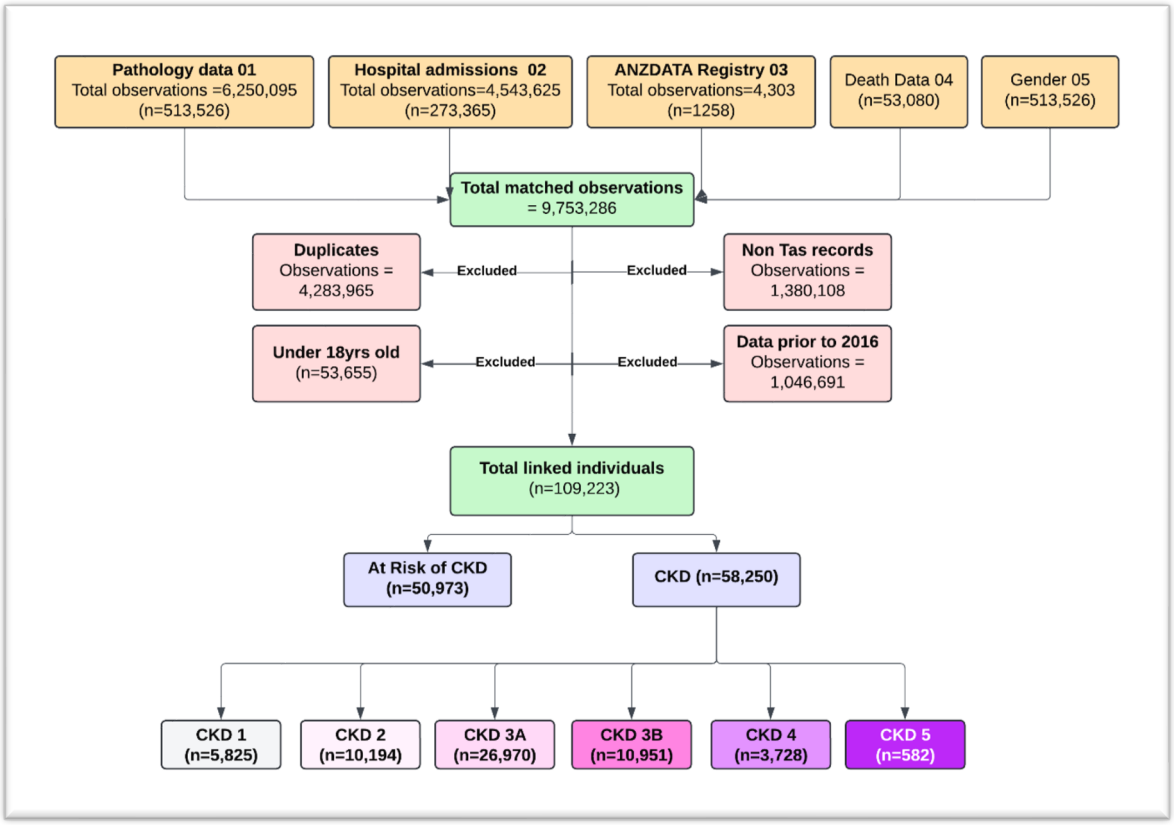

Figure 4: Datasets making up the Tasmanian cohort

2.3 CKD targeted screening and identification

CKD targeted screening and identification was assessed against the KHA 2015 Guidelines (20) including:

1. Variables and definitions
2. At-risk definitions

KHA describes several risk factors and conditions as indicators for regular kidney health assessments. Table 1 identifies the risk factor, whether it was present in the respective jurisdictional dataset, how it was defined and whether it was used. Data available to define risk factors and, therefore, identify the comorbidity status of individuals was limited in comparison with the data available to determine adherence to screening and management guidelines. It was possible to identify a risk factor using different coded variables such as ICD, ICPC and Recorded Status (Y/N or 1/0); however, pathology and observation data were not used to diagnose risk factors in the absence of a recorded status.

While some risk factors were present in the datasets, they may not have been used in the analysis. For example, the study did not have ethical clearance to analyse datasets by Indigenous status for Tasmania and therefore Indigenous status was not a risk factor included in the analyses for any of the datasets (Table 1).

Table 1: Data used to define CKD risk factors in each dataset

Risk Factor	TKC	Western Melbourne	Tasmania
Diabetes	Either ICD, ICPC, recorded status (Y/N)	Recorded status (Y/N)	ICD codes (first 30)
Hypertension	Either ICD, ICPC,	Recorded status (Y/N)	ICD codes
CVD – stroke, peripheral vascular disease, coronary artery disease	Either ICD or ICPC status	Recorded status (Y/N)	Either ICD or recorded status
Obesity	BMI>30	BMI>30	ICD
Smoker	X	Present in data but not used in study	X
Family history of kidney failure	X	X	X
Aboriginal or Torres Strait Islander origin >=30 years	Present in data but not used in this analysis	Present in data but not used in this analysis	X
Acute kidney injury (AKI)	X	X	X
At-risk	Any of the above	Any of the above	Any of the above

X=Not present in dataset

2.3.1 CKD stages

CKD is a progressive condition characterised by a gradual loss of kidney function over time. The kidneys are essential for filtering waste and excess fluids from the blood. Early detection and treatment are crucial for slowing the progression of CKD, managing symptoms, and reducing the risk of associated health problems. CKD is commonly divided into five stages based on the estimated glomerular filtration rate (eGFR) – a calculation from serum creatinine. In recent times, the importance of albumin in urine (signifying protein loss) has been highlighted and recommendations to include urinary albumin-creatinine ratio (uACR) in the staging guidelines were made by national and international bodies (21, 22). In each stage of CKD, specific evidence-based management strategies are recommended to delay progression and alleviate symptoms.

2.3.2 CKD targeted screening

In our analysis, targeted screening for kidney disease and disease progression (kidney health checks) was based on the presence of an eGFR ***and*** uACR. The 'intent to screen' is the presence of both tests. Adult health checks include screening for kidney disease and are recommended every one to two years for those with risk factors. Automatic reporting of eGFR with requests for serum creatinine concentrations in adults has been standard procedure from laboratory services across Australia since 2005. In 2012, it was recommended that the calculation be changed to the CKD-EPI formula to provide precise estimations of kidney function (21). As eGFR reporting may occur with blood tests taken for other reasons, the *intent to screen for CKD* has been defined as the presence of both an eGFR and uACR. As BP was not available in all data sets, we did not include BP in screening activities.

The KHA guidelines use an 'at a glance' colour-coded matrix to assist clinicians in easily determining a patient's risk, CKD stage and recommended management plan based on the eGFR and uACR. Treatment goals and clinical management plans are aligned to colours:

- Green (regular screening)
- Yellow (determine underlying cause, reduce risks and progression)
- Orange (early detection of complications and appropriate prescribing and referral)
- Red (prepare for kidney replacement therapy (KRT) or supportive care if appropriate) (Figure 5).

Guidelines did not change discernably between 2012 and 2015, other than to provide greater advice to GPs around investigating other presentations for possible kidney disease involvement e.g. hepatitis variants, systemic or connective tissue diseases. Given the minimal changes in guidelines during the interest period (2010–2020), we have assessed management against the KHA 2015 Guidelines (20).

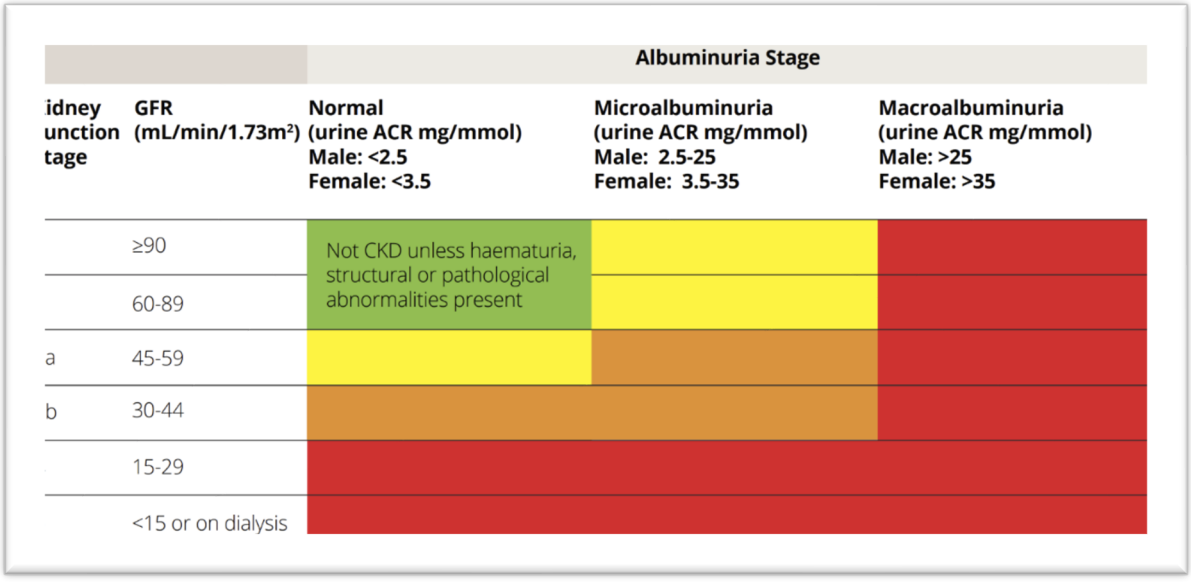

Figure 5: Kidney Health Australia Quick Reference Guide to CKD Stage (20)

2.3.3 Defining CKD

The following criteria and methods were used to define CKD and CKD stage in each dataset:

a. eGFR was calculated from serum creatinine using CKD-EPI formula (23)

b. Albuminuria was defined as uACR >=2.5mg/mmol for male and >=3.5mg/mmol for female, as per the KHA guideline (20)

c. CKD was defined and staged using eGFR (recorded or calculated) and recorded uACR measures, and confirmed with two tests >=90 days apart but within 365 days to determine persistence as per the KDIGO (22) and KHA guidelines. For multiple test results on same dates, the lowest value of eGFR was used.

d. CKD stage was carried forward until next creatinine/eGFR measurement indicated a progression to the next/highest stage, although a person could only be in one stage per year based on the last result.

2.4 CKD Management

CKD management was assessed against the KHA Clinical Action Plans, which included regular monitoring, management of comorbid conditions (appropriate medication) and attainment of clinical targets. Monitoring was according to the respective Clinical Action Plans (Yellow, Orange or Red) and management was assessed against the availability and results of observations and pathology data. Care plans were not available in any of the datasets.

a. Glycaemic control was based on either fasting blood glucose (FBG) 6-8mmol/L or postprandial/random blood glucose (RBG) 8-10 mmol/L or HbA1c ≤7% (range 6.5-7.5) or ≤53 mmol/mol (range 48-58), and

b. Blood pressure control was based on the availability of BP recordings, with targets set at ≤ 140/90 mmHg or ≤ 130/80 mmHg for people with albuminuria (urine ACR >3.5 mg/mmol in females and >2.5 mg/mmol in males) or diabetes.

3 Chapter 3 – Results

KEY POINTS

1. The characteristics of patients in the datasets vary. All datasets report more females than males in 'at-risk' groups
2. TKC has a markedly younger cohort with more than 70% below the age of 55 years
3. CVD rates are significantly higher in the Tasmanian dataset compared to both the TKC and Western Melbourne datasets
4. Overall, the study indicates that targeted screening of 'at-risk' people remains a challenge
5. Comparisons between the datasets are problematic given the very different derivations and purposes of each dataset
6. The inability to host the data on a local server and the restricted access has limited the ability to undertake repeat analysis

3.1 Characteristics of the cohort

This section presents the characteristics of patients in the CKD Consortium cohorts (Table 2). Each cohort was created using different datasets and time frames and thus meaningful comparisons across cohorts are challenging.

1. The TKC dataset includes a subset of the population in the NT that had an episode of care in public health services, that is, hospitals and mostly remote primary health facilities. It is the only dataset of the three that includes both primary and tertiary level data, but it is also the only set that required the individual to have a CKD diagnosis or risk factor for inclusion. Only patients who have a primary health episode of care are included. The dataset includes both ICPC and ICD codes.
2. The Western Melbourne dataset includes primary health data from participating private GP practices in the Western Melbourne area. It does not include all the GP practices in the area, and it does not include hospital data. Data includes individuals who attended the health service regardless of the presence of CKD diagnosis or risk factor. The dataset does not include ICD codes.
3. The Tasmanian dataset is linked data from multiple sources including Tasmanian hospitals and pathology services and the national ANZDATA Registry. The dataset does not include management data from primary health services and, therefore, does not contain ICPC codes. The criteria for inclusion in the Tasmanian dataset is an admission to hospital and, thus, includes ICD codes.

3.1.1 TKC – Northern Territory

The TKC cohort (2016 to 2020) of 28,381 active individuals includes 12,292 at-risk of CKD (i.e. diabetes, hypertension, CVD or obesity) and 16,089 individuals with CKD. Men constituted 46.6% of the at-risk group and 41.6% of the CKD group. Age distribution reveals a much younger cohort for both those at-risk and with CKD, which is markedly different from the other jurisdictions with approximately 70% of both groups aged below 55 years. Obesity is the most common comorbidity among the at-risk group (49.0%), while diabetes is more prevalent in the CKD patients (49.3%) (Table 2).

3.1.2 Western Melbourne

In the Western Melbourne cohort of 53,067 active individuals (2015 to 2019), 16,524 at-risk individuals were identified alongside 2,910 individuals with CKD (Table 2). Men constituted 42.0% of the at-risk group and 46.0% of the CKD group. There was a difference in the age distribution between those at-risk and those with CKD with approximately 50% of the at-risk group aged 55 years and over while nearly 90% of those with CKD were aged 55 years and over. Obesity was the most prevalent (77.0%) comorbidity among those at-risk followed by hypertension (45.0%). In contrast, hypertension was the most prevalent (70.0%) comorbidity in individuals with CKD followed by obesity (39.0%).

3.1.3 Tasmania

In the Tasmanian dataset, between 2016 and 2020, of the total 109,224 individuals in the dataset, 50,973 had at least one chronic condition risk factor (i.e. diabetes, hypertension, CVD or obesity), and 58,251 individuals were identified with CKD (Table 2). Men constituted 44.4% of the at-risk group and 52.9% of the CKD group. Similar to the Western Melbourne profile, nearly 60% of individuals at-risk were aged 55 years and over, while just over 85% with CKD were aged 55 years and over. Comorbid conditions in the at-risk group were different when compared to TKC and Western Melbourne, with hypertension being the most prevalent condition (51.9%) as opposed to obesity (7.1%). For those with CKD, hypertension was also the most prevalent condition (36.5%) followed by diabetes (26.9%).

Table 2: Characteristics of the At Risk and CKD cohorts 2016-2019

Characteristic	TKC		Western Melbourne		Tasmania	
	At risk	CKD	At risk	CKD	At risk	CKD
	N = 12,292	N = 16,089	N = 16,524	N = 2,910	N = 50,973	N = 58,251
Gender, n (%)						
Male	5,857 (47.6)	7,008 (43.6)	6940 (42.0)	1339 (46.0)	22,621 (44.4)	30,816 (52.9)
Female	6,435 (52.4)	9,081 (56.4)	9584 (58.0)	1571 (54.0)	28,352 (55.6)	27,434 (47.1)
Age Group, n (%)						
18-24	1,434 (11.7)	1,937 (12.0)	766 (4.6)	13 (0.5)	1,844 (3.6)	271 (0.5)
25-34	2,306 (18.8)	2,979 (18.5)	1,863 (11.0)	35 (1.2)	2,488 (4.9)	624 (1.1)
35-44	2,301 (18.7)	3,412 (21.2)	2,762 (17.0)	80 (2.8)	5,689 (11.2)	1,734 (3.0)
45-54	2,504 (20.4)	3,427 (21.3)	3,131 (19.0)	176 (6.0)	10,773 (21.1)	5,344 (9.2)
55-64	2,283 (18.6)	2,414 (15.0)	3,281 (20.0)	335 (11.5)	14,147 (27.7)	12,808 (22.0)
65-74	1,162 (9.5)	1,268 (7.9)	3,000 (18.0)	788 (27.0)	10,620 (20.8)	18,096 (31.1)
75-84	262 (2.1)	538 (3.3)	1,355 (8.2)	926 (32.0)	4,591 (9.0)	15,018 (25.8)
85+	40 (0.3)	114 (0.7)	366 (2.2)	557 (19.0)	821 (1.6)	4,355 (7.5)
Diabetes, n (%)	4,480 (36.4)	7,399 (46.0)	2,755 (16.7)	1,030 (35.4)	23,866 (46.8)	15,680 (26.9)
Hypertension, n (%)	5,264 (42.8)	6,782 (42.2)	7,506 (45.0)	2,022(69.0)	26,479 (51.9)	21,258 (36.5)
CVD, n (%)	2,134 (17.4)	2,600 (16.2)	176 (1.2)	258 (9.0)	19,953 (39.1)	13,801 (23.7)
Obesity, n (%)	5,691 (46.3)	4,956 (30.8)	11,505 (77.0)	1,132 (39.0)	3,618 (7.1)	1,557 (2.7)

3.1.4 Discussion

The characteristics of patients in the datasets vary. All datasets report more females than males in at-risk groups. The Tasmanian dataset is the only one to report more males with CKD, potentially because this dataset included minimal primary care data, and women are known to attend primary care appointments more frequently than men (24). In the NT, there are more females with CKD, and our experience is that this translates to more females receiving KRT. However, Western Melbourne also reports more females with CKD, but this does not translate to more females on KRT (25).

TKC has a markedly younger cohort with more than 70% below the age of 55 years. This is likely to reflect the NT cohort in TKC, which is made up largely of First Nations people, primarily from remote and very remote areas. We know this cohort has significantly higher comorbidities and rates of kidney disease than elsewhere in Australia (26, 27). The older age groups in the other datasets are reflective of the Australian profile for CKD in general.

The lower rates of obesity in the Tasmanian cohort are notable and possibly a reflection of poor ICD coding in hospital datasets, as well as the absence of BMI. Obesity tends to be better documented in primary health data through both BMI results and ICPC codes.

Conversely, CVD rates are significantly higher in the Tasmanian dataset compared to both the TKC and Western Melbourne datasets. Again, this is likely to reflect how this information is captured, with ICD

coding for a range of cardiovascular conditions available in hospital datasets but fewer items available in primary health datasets. Additionally, data extraction for TKC focussed on documented cardiovascular risk (CVR) results of greater than 15, which may have limited the identification of cardiac conditions.

3.2 Temporal trends in CKD screening among at-risk individuals

This section investigates the percentage of individuals at-risk of CKD in each dataset who had yearly/biennial eGFR and uACR tests as per the KHA (2015) guidelines (20), stratified by gender and specific comorbid (at-risk) conditions of diabetes, hypertension, cardiovascular disease and obesity. We have reported only data from 2015 onwards from the Tasmanian dataset to provide comparative trends in the below graphs.

3.2.1 TKC – Northern Territory

Over the study period of 2016 to 2020, the number of people at-risk of CKD in the TKC dataset, who were screened for CKD (both eGFR and uACR), decreased from 2016 to 2017 but increased annually afterwards. The percentage who received only an eGFR showed the same trend (Figure 6). Screening for CKD was assessed as an annual activity, given the high-risk population in the NT, and encouraged through the availability of the annual health check (MBS item 715, which is specifically for GP health assessments for Aboriginal and Torres Strait Islander peoples). KHA recommends utilising this item for annual screening where applicable (20).

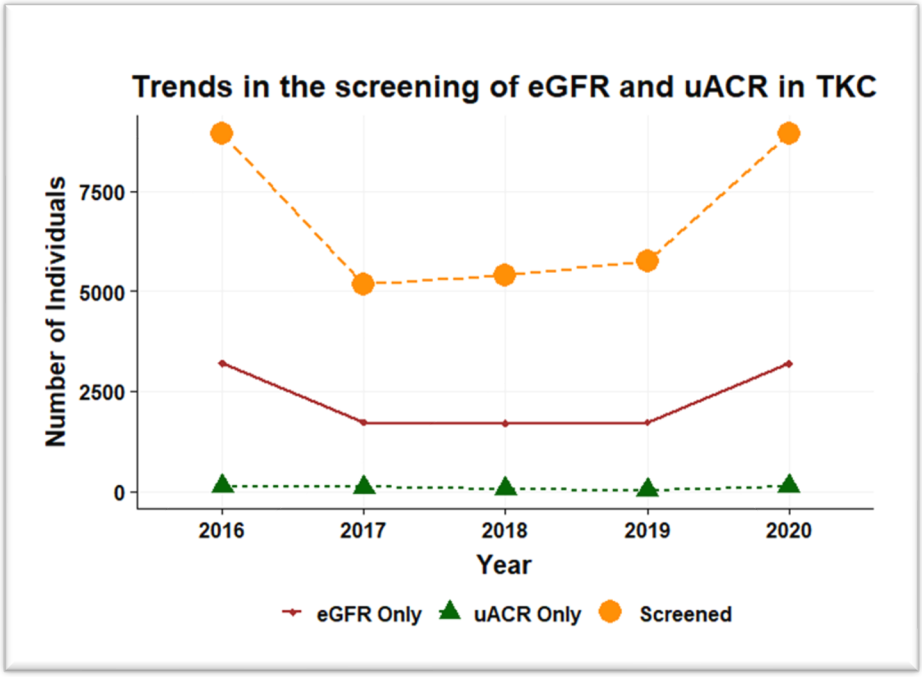

Figure 6: Trends in the number of individuals screened annually in TKC dataset

We also compared the percentage of active individuals who did not receive any form of screening (eGFR or uACR) with those that did. The *intent to screen* remained relatively stable between 2017 to 2019 (55% to 51%) although this was lower than screening rates in both 2016 and 2020. There was an inverse relationship with the percentage of individuals that did not receive any tests during the same period with lower rates in 2016 and 2020 but higher in the middle years (Figure 7). There did not appear to be any difference in screening rates between males and females (Figures 8).

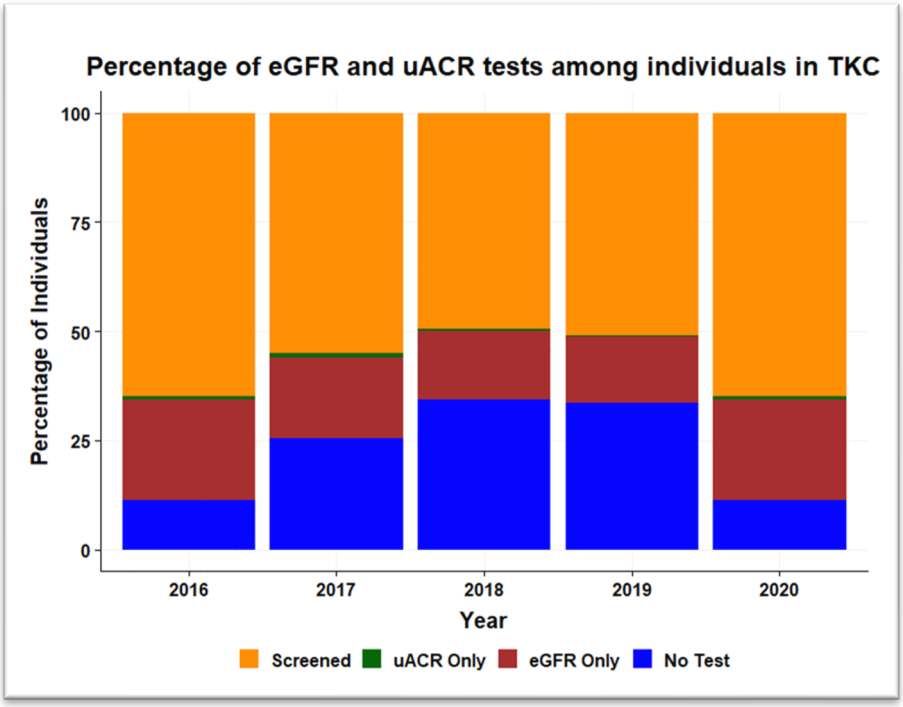

Figure 7: Trends in the percentage of individuals screened annually in TKC dataset

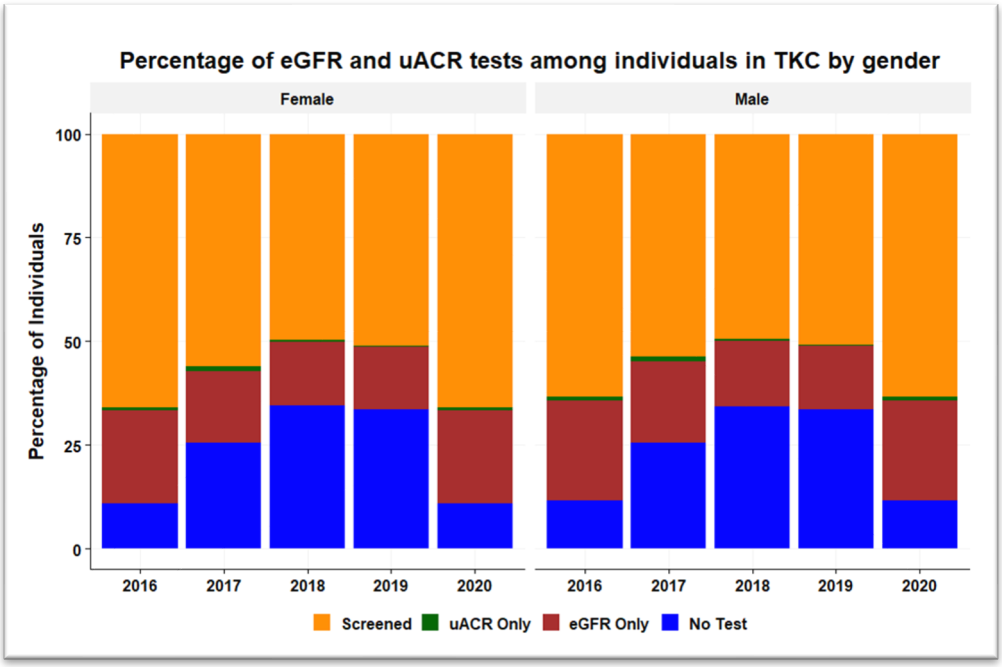

Figure 8: Trends in the percentage of individuals screened annually by gender in TKC dataset

Trends in the screening for CKD amongst individuals with risk factors of diabetes, hypertension (HTN), cardiovascular disease (CVD) and obesity are presented in Figure 9. Overall, from 2016 to 2020, approximately 50 to 65% of at-risk individuals were screened annually with rates across the years reflecting the trend already noted above. For selected comorbidities (Figure 9) screening was higher particularly for individuals with diabetes and hypertension. This is likely to reflect the cohort in TKC who are a high-risk group made up largely of First Nations people with multimorbidity. Local guidelines

recommend annual health checks for Aboriginal and Torres Strait Islander peoples, which are incentivised through the MBS 715 item.

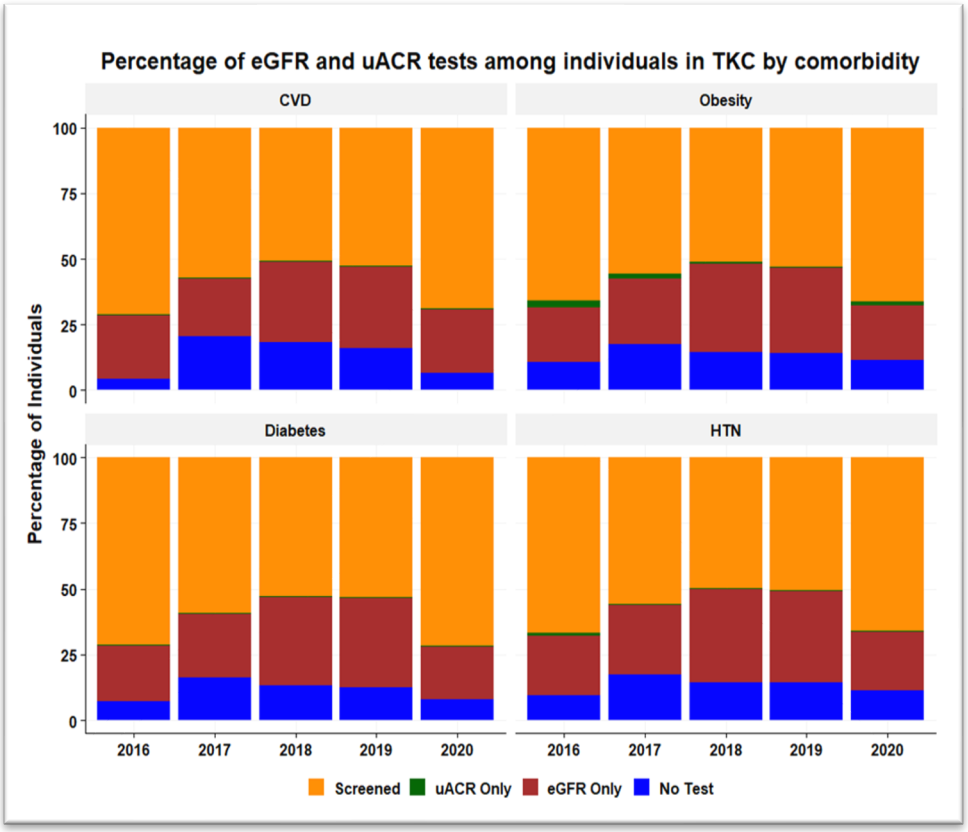

Figure 9: Trends in the percentage of individuals screened annually by comorbidity in TKC dataset

3.2.2 Western Melbourne

The yearly trend of both eGFR and uACR tests (targeted screening) among at-risk individuals in the Western Melbourne dataset demonstrated a slight trend downwards from a high in 2017 (Figure 10). The low numbers in 2015 and 2016 are likely reflective of the data extraction method which includes greater numbers of patients from 2017 onwards but included retrospective data for the previous 2 years.

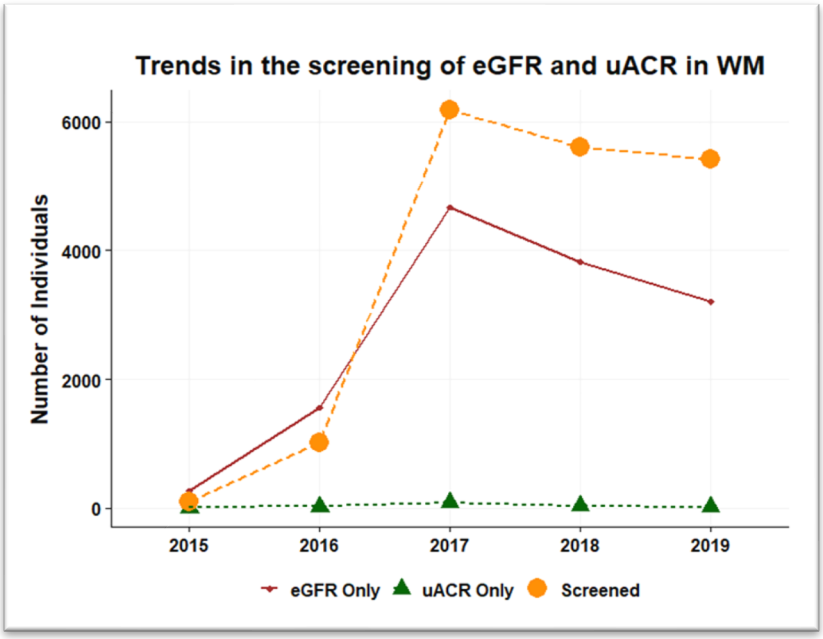

Figure 10: Trends in the number of individuals screened annually in Western Melbourne dataset

The yearly trend of both eGFR and uACR tests (screened) among at-risk individuals in the Western Melbourne dataset increased from 18.5% in 2015 to 34.1% in 2019, although the percentage of active individuals who did not receive any tests also trended upwards from 33.2% in 2015 to approximately 45.7% in 2019 (Figure 11). This may reflect the changing base denominator as patients were identified and moved from At Risk to the CKD cohort. Additionally, guidelines only require screening every two years for patients at risk, with annual screening only recommended for those with diabetes and hypertension.

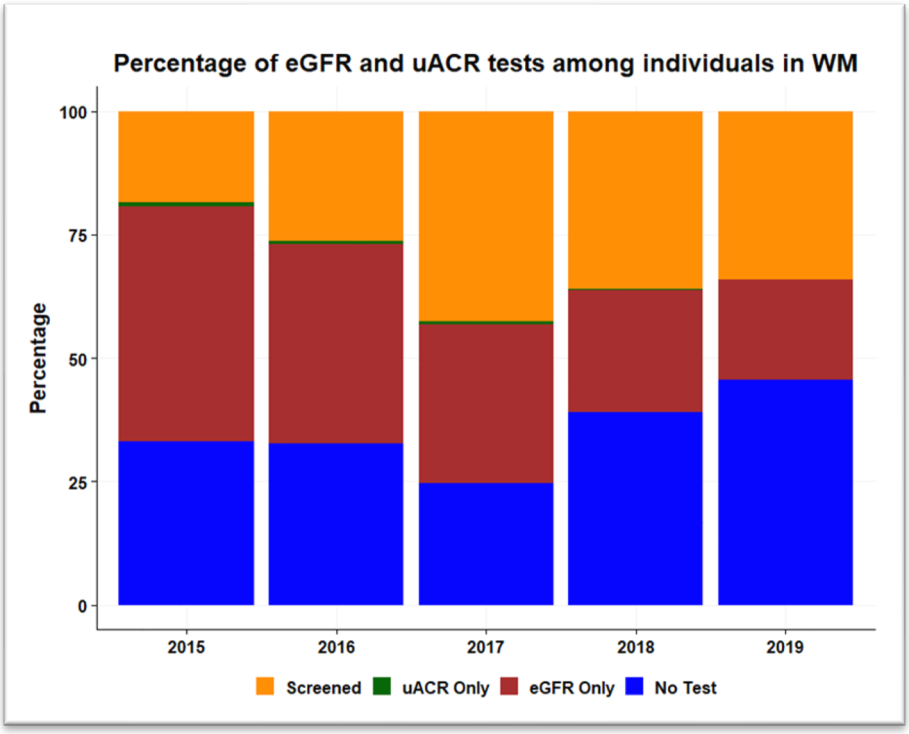

Figure 11: Trends in the percentage of individuals screened annually in Western Melbourne dataset

Although there were more females in the dataset than males, there was a slight disparity in testing with females less likely to be screened (both eGFR and uACR). However, the proportion and trajectory of those that did not receive any testing were similar between the genders (Figure 12).

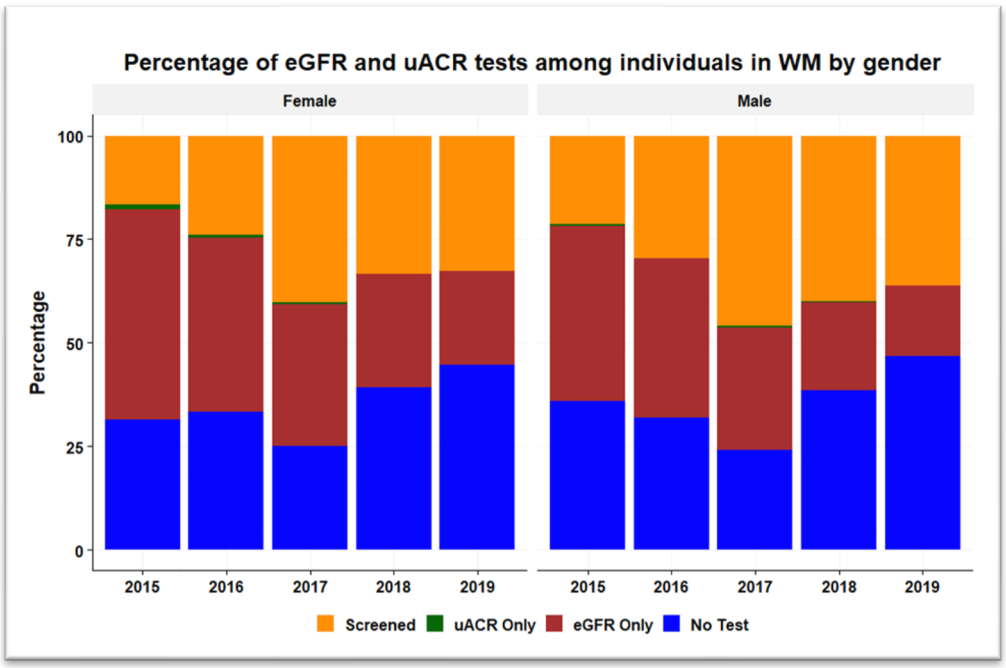

Figure 12 Trends in the percentage of individuals screened annually by gender in Western Melbourne dataset

We also assessed targeted screening rates of at-risk individuals in Western Melbourne dataset by specific condition. Individuals were assessed for annual target screening although KHA guidelines, recommend biennially for those with CVD and obesity. Our approach may have under-estimated screening for these conditions. There were higher rates of targeted screening for those with diabetes compared to other conditions (hypertension, CVD, and obesity) with annual targeted screening rising from 42.8% in 2015 to 56.2% in 2019 (with a high of 75% in 2017) (Figure 13). Conversely, targeted screening of individuals with CVD, hypertension and obesity declined from 2017 to 2019 with a corresponding upward trend in the percentage who did not receive any testing. Again, this may reflect the moving denominator as patients moved from At Risk to CKD but also a lower requirement to test annually for CVD and obesity.

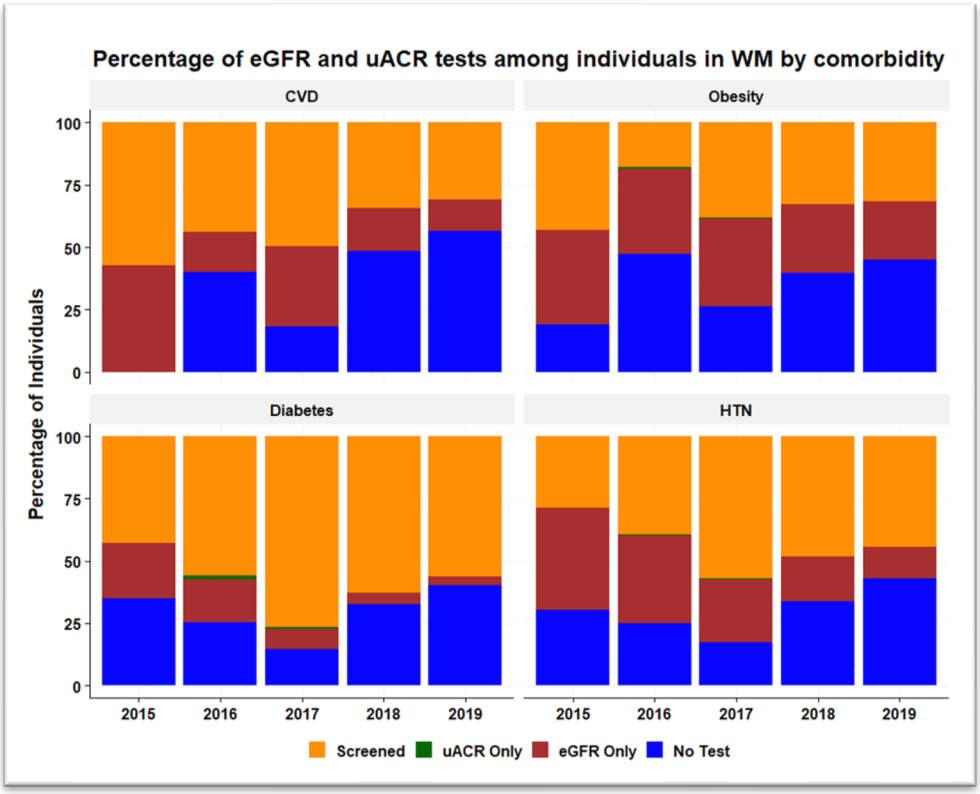

Figure 13: Trends in the percentage of individuals screened annually by comorbidity in Western Melbourne dataset

3.2.3 Tasmania

The yearly trend of both eGFR and uACR tests among at-risk individuals in the Tasmanian dataset between 2015–2020 remained stable, although there was a slight increase in the number of people who received an eGFR only (Figure 14).

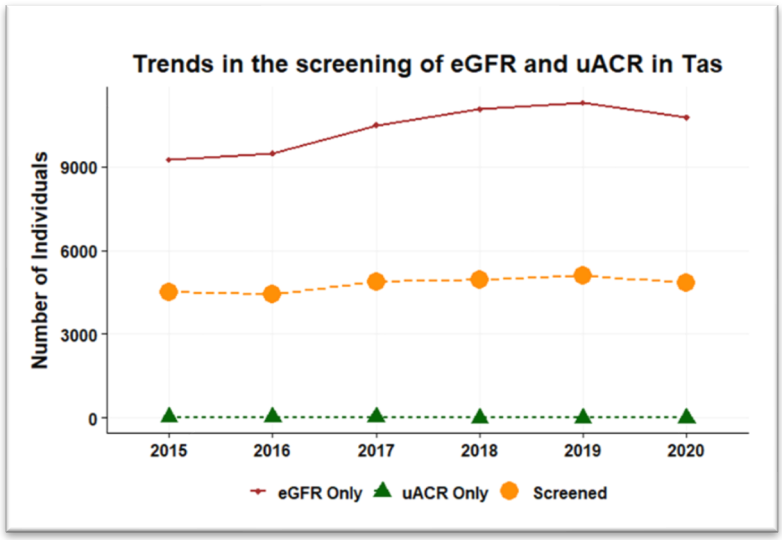

Figure 14: Trends in the number of individuals screened annually in Tasmanian dataset

The percentage of individuals screened over the same period remained relatively stable, at around 22–25%, and does not demonstrate the same level of fluctuations between years as seen in the other datasets (Figure 15). The Tasmanian dataset does not include primary health data, and this may account for the low recording of uACR, as this test is more likely to be undertaken in the primary health care setting.

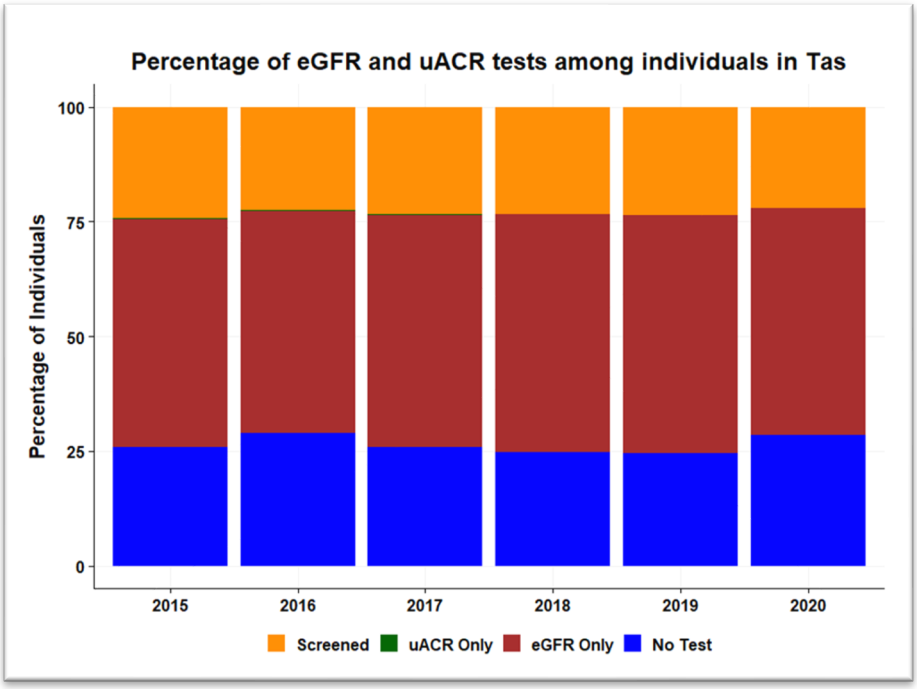

Figure 15: Trends in the percentage of individuals screened annually in Tasmanian dataset

Although there are more males compared to females in the dataset, there is no significant difference in targeted screening for CKD between the genders (Figure 16).

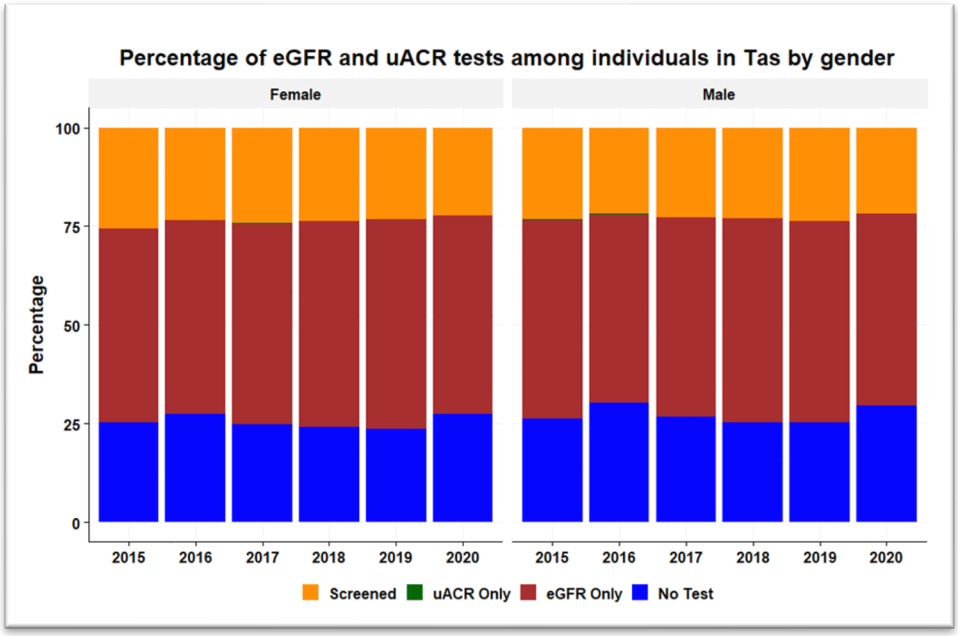

Figure 16: Trends in the percentage of individuals screened annually by gender in Tasmanian dataset

The trends of yearly/biennial tests among at-risk individuals with diabetes, hypertension, CVD and obesity in the Tasmanian dataset are presented in Figure 17. As with the Western Melbourne dataset, the percentage of individuals screened annually for CKD was higher among those with diabetes compared to other conditions (HTN, CVD and obesity) and remained relatively stable at approximately 40% between 2016 to 2020. Individuals with hypertension had significantly lower rates of annual targeted screening with approximately 16% screened each year. The percentage who did not receive any tests in this group demonstrated a slight trend upwards but remained less than 30%.

In contrast, the percentage of individuals with CVD and obesity who did not receive any tests when assessed biennially was comparatively low when compared to the other jurisdictions, at less than 20%. However biennial targeted screening was also low for both CVD (<20%) and obesity (<25%) and likely reflects the low levels of uACR in the Tasmanian dataset (Figure 17).

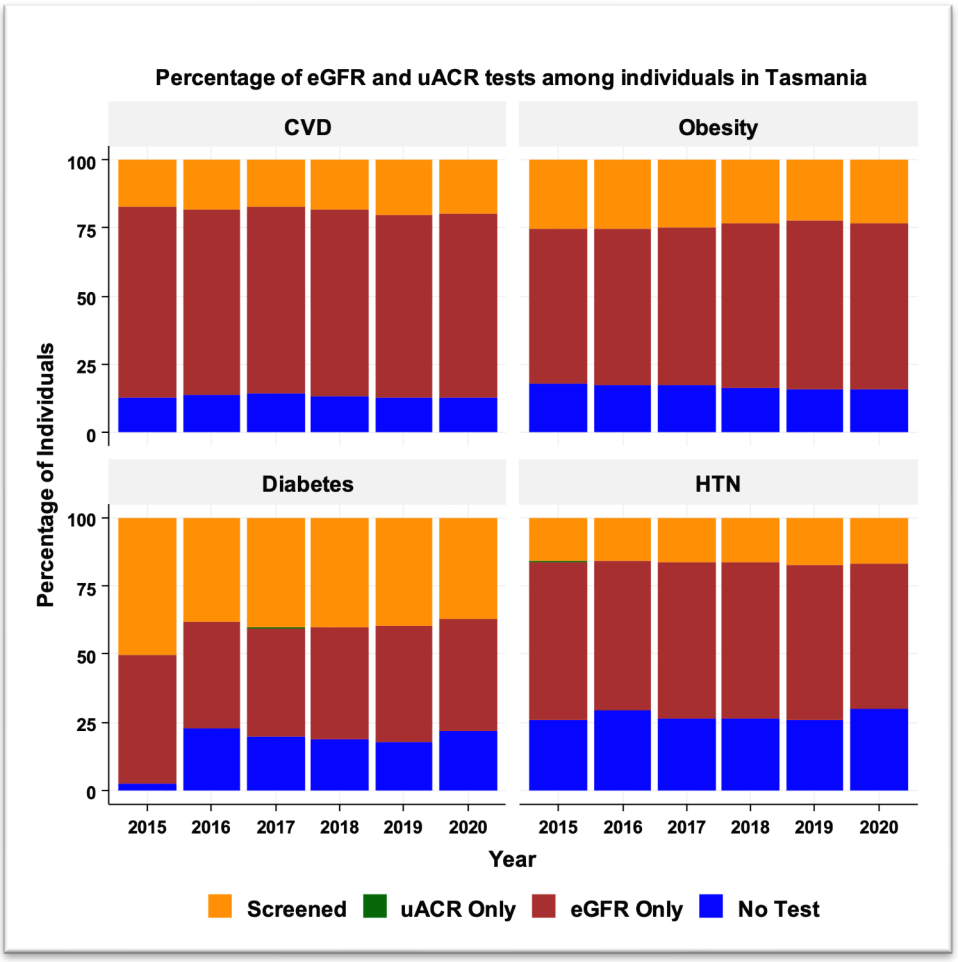

Figure 17: Trends in the percentage of individuals screened annually by comorbidity in in Tasmanian dataset

3.2.4 Discussion

Overall, our study indicates that targeted screening of at-risk people remains a challenge. The TKC dataset demonstrated the highest rates of *intent to screen* with both eGFR and uACR. In the NT, annual targeted screening is recommended for high-risk patients such as First Nations people and is incentivised through the MBS item for Aboriginal and Torres Strait Islander adult health assessments. Despite this, and the focus of the TKC dataset on people with risk conditions for kidney disease, just over half of the people that should have received annual targeted screening, according to guidelines, were screened between 2016 and 2020. People with diabetes and CVD, highly prevalent risk factors in the TKC cohort, were more likely to be screened, with rates of targeted screening at 71.7% and 68.8%, in 2016 and 2020 respectively.

The Western Melbourne data set reflected higher rates of targeted screening in 2017 than in the earlier or later years of the analysis. Targeted screening was higher for specific comorbidities such as diabetes and hypertension but still reflected the same pattern. As the data was extracted at different timepoints between 2017 and 2019, the lower rates of screening are likely to reflect the lower levels of data for these patients in the previous years and possible movement out of the at-risk category and into the CKD cohort in the latter years.

In contrast, according to our analysis, overall targeted screening of at-risk people in the Tasmanian dataset were lower at approximately 25%. These differences are likely due to the methodology which follows the KHA guideline of requiring both eGFR and uACR for targeted screening, and the absence of primary health management information. This is not to say that patients did not receive appropriate management based on a single test, but we are unable to determine follow-up from this analysis alone. In all datasets, targeted screening for diabetes was higher than for the other comorbidities and reflects an increasing awareness to screen diabetics for kidney disease as part of routine care. The data suggests a greater focus on obesity as a risk factor for CKD is required to improve screening rates.

3.3 Temporal trends in the monitoring and management of CKD

This section assesses whether CKD care (monitoring and management) was consistent with guidelines across the 3 datasets. We limited the analysis to the years 2016–2019 for all datasets to increase opportunities for comparisons in monitoring. However, the datasets are substantively different, and direct comparisons were not possible for all measures.

The coloured ‘at a glance’ approach to the identification of CKD stages (see Figure 5) depicted in the KHA handbook (20) are associated with ‘Clinical Action Plans’ for each colour. The Clinical Action Plans provide recommendations for monitoring and management according to eGFR and albuminuria results. The recommendations according to the Clinical Action Plans are as follows:

1. **Yellow:**
    1. Goals of management: investigations to exclude treatable conditions, reduce cardiovascular (CVD) risk, and avoidance of medications or activities that further damage the kidneys.
    2. Monitoring: 12-monthly clinical reviews, BP, weight, uACR, eGFR, HbA1c (for people with diabetes), fasting lipids, urea and electrolyte blood panel.
    3. Absolute CVD risk assessment: use the recommended AusCVD Risk Calculator and provide lifestyle and medication strategies according to risk profile.
    4. Lifestyle modifications: smoking cessation, weight reduction, low-salt diet, exercise etc.
    5. Management: BP target ≤ 140/90 or ≤ 130/80 for those with albuminuria, commence ACE inhibitors, glycaemic control < 7.0% (for people with diabetes).
2. **Orange:**
    1. Goals of management: investigations to exclude treatable conditions, reduce CKD progression, reduce CVD risk, avoidance of nephrotoxic medications or activities that further damage the kidneys, early detection and management of complications, referral to a nephrologist if indicated.
    2. Monitoring: 3–6 monthly clinical reviews, BP, weight, uACR, eGFR, HbA1c (for people with diabetes), fasting lipids, urea and electrolyte blood panel, calcium and phosphate, parathyroid hormone.
    3. Absolute CVD risk assessment: considered high CVD risk, provide lifestyle and medication interventions, e.g. smoking cessation, weight reduction, low-salt diet, exercise, etc.
    4. Management: BP reduction BP target ≤ 140/90 or ≤ 130/80 for those with albuminuria, medication management (ACE inhibitors or ARBs, lipid-lowering agents), glycaemic control < 7.0% (for people with diabetes).
3. **Red:**
    1. Goals of management: referral to nephrologist, prepare for dialysis/pre-emptive transplant, multidisciplinary team involvement, discuss advanced care directive, reduce CKD progression, CVD risk, titrate medications for kidney function, detection and management of complications.
    2. Monitoring: 1–3 monthly clinical reviews, BP, weight, oedema, uACR, eGFR, HbA1c (for people with diabetes), fasting lipids, urea and electrolyte blood panel, calcium and phosphate, parathyroid hormone.
    3. Management: considered high CVD risk, provide lifestyle and medication interventions, e.g. smoking cessation, weight reduction, low-salt diet, exercise, BP target ≤ 140/90 or ≤ 130/80 for those with albuminuria, medication management (ACE inhibitors or ARBs, lipid-lowering agents), glycaemic control < 7.0% (for people with diabetes).
    4. Referral to a nephrologist at least 12 months prior to commencement of dialysis.

Assessing adherence to the KHA management guidelines (20) in each jurisdiction is limited by the data available in each dataset. Care plans were not available in any of the datasets, while smoking cessation and medications were only available in one dataset. Assessing adherence to the guidelines has thus focused on: Monitoring (timely clinical review, BP, uACR, eGFR, HbA1c); and Management (targets for BP and HbA1c).

3.3.1 Distribution of CKD across cohorts

The distribution of CKD by stages and across the years 2016 to 2019 for each jurisdiction is detailed in Table 3. As described earlier, the datasets are a subset of the populations within each jurisdiction and have different inclusion and exclusion criteria. It is not possible to present the information as a proportion of the population and, therefore, we are unable to report the population prevalence of CKD.

In the TKC dataset, from 2016 to 2019, CKD patient numbers grew from 10,323 to 16,617, with the majority consistently diagnosed in the earliest stage (Stage 1), which is approximately 60% of cases.

CKD cases in the Western Melbourne dataset, while considerably lower, also increased between 2016 and 2019 from 799 to 2345, with the majority of cases diagnosed in the early stages (CKD 1–3a).

Similarly, in the Tasmanian dataset, the number of CKD cases rose by 6% from 31,793 in 2016 to 33,709 in 2019, with about 74% making up early-stage CKD (CKD1–3a).

Table 3: Distribution of CKD stages among active patients in (A) TKC; (B) Western Melbourne; (C) Tasmania 2016 to 2019

CKD stages, n (%)	2016	2017	2018	2019
(A) TKC				
CKD 1	6114 (59.2)	8272 (59.1)	9144 (58.5)	9656 (58.1)
CKD 2	2920 (28.3)	3653 (26.1)	4051 (25.9)	4358 (26.2)
CKD 3A	711 (6.9)	1087 (7.8)	1232 (7.9)	1298 (7.8)
CKD 3B	302 (2.9)	450 (3.2)	533 (3.4)	541 (3.3)
CKD 4	169 (1.6)	266 (1.9)	381 (2.4)	434 (2.6)
CKD 5	107 (1.0)	260 (1.9)	303 (1.9)	330(2.0)
Total	**10323**	**13988**	**15644**	**16617**
(B) Western Melbourne				
CKD 1	83 (10.4)	132 (6.9)	145 (8.9)	164 (8.2)
CKD 2	284 (35.5)	488 (25.8)	618 (38.0)	672 (33.5)
CKD 3A	238 (29.8)	454 (23.9)	656 (40.4)	763 (38.0)
CKD 3B	130 (16.3)	249 (13.1)	399 (24.6)	476 (23.7)
CKD 4	29 (3.6)	58 (3.0)	118 (7.3)	150 (7.5)
CKD 5	35 (4.4)	513 (27.0)	237 (14.6)	120 (6.0)
Total	**799**	**1894**	**2173**	**2345**
(C) Tasmania				
CKD 1	3140 (9.8)	3376 (10.2)	3383 (4.0)	3368 (10.0)
CKD 2	4847 (15.2)	5358 (16.2)	5589 (16.8)	5879 (17.4)
CKD 3A	15357 (48.3)	15532 (47.0)	15520 (46.6)	15619 (46.3)
CKD 3B	6021 (18.9)	6179 (18.7)	6204 (18.6)	6310 (18.7)
CKD 4	2115 (6.6)	2181 (6.6)	2235 (6.7)	2167 (6.4)
CKD 5	313 (09)	355 (1.0)	398 (1.2)	366 (1.0)
Total	**31,793**	**32,981**	**33,329**	**33,709**

3.3.2 Distribution of CKD according to heatmap

In this section, for each jurisdiction, we analysed trends and distributions of CKD stage according to the heatmap in the KHA Guidelines (20). We mapped the distribution of CKD patients in each category by eGFR and albuminuria across the 3 jurisdictions from 2016 to 2019. The yellow group consistently demonstrated the highest prevalence across all regions, accounting for approximately half of all cases in TKC and over a third of cases in Western Melbourne and Tasmanian data sets. The TKC dataset reported the highest number of cases across yellow and red-action groups, reflecting the high levels of macroalbuminuria in the patient population, particularly in CKD stages 1 and 2.

Conversely both the Western Melbourne and Tasmanian datasets showed lower percentages of people with macroalbuminuria but higher percentages of people in the orange action groups, which made up 20–25% of their cohorts. It is important to note that the number of individuals represented on the heatmap for the Tasmanian dataset only reflects those who had an uACR. Therefore, the numbers are very low in comparison to the number of individuals with CKD. See Table 4 for a detailed heatmap of each dataset.

Table 4: Number of individuals in yellow, orange, and red action groups for CKD in the three datasets

CKD stages	eGFR (mL/min/1.73 m^2)	urine Albuminuria (uACR) categories (mg/mmol)			urine Albuminuria (uACR) categories (mg/mmol)			urine Albuminuria (uACR) categories (mg/mmol)			urine Albuminuria (uACR) categories (mg/mmol)		
		Normal	Micro	Macro	Normal	Micro	Macro	Normal	Micro	Macro	Normal	Micro	Macro
TKC			**2016**			**2017**			**2018**			**2019**	
1	>89		3587 (34.7)	1188 (11.5)		4296 (34.7)	1394 (11.3)		4915 (34.8)	1429(10.1)		5176 (33.6)	1463 (9.5)
2	60-89		1649 (16.0)	874 (8.5)		1855 (15.0)	938 (7.6)		2047 (14.5)	1052 (7.5)		2302 (14.9)	1077 (7.0)
3a	45-59	270 (2.6)	196 (1.9)	245 (2.4)	345 (2.8)	226 (1.8)	278 (2.2)	426 (3.0)	266 (1.9)	285 (2.0)	487 (3.2)	269 (1.7)	323 (2.1)
3b	30-44	52 (0.5)	70 (0.7)	180 (1.7)	68 (0.5)	96 (0.8)	208 (1.7)	101 (0.7)	95 (0.7)	236 (1.7)	106 (0.7)	100 (0.6)	250 (1.6)
4	15-29	10 (0.1)	19 (0.2)	140 (1.4)	20 (0.1)	37 (0.3)	159 (1.3)	24 (0.2)	36 (0.3)	188 (1.3)	31 (0.2)	33 (0.2)	215 (1.41)
5	<15 or dialysis	1 (0.01)	4 (0.04)	102 (1.0)	2 (0.02)	7 (0.6)	188 (1.5)	6 (0.04)	9 (0.1)	294 (2.1)	12 (0.08)	10 (0.06)	355 (2.3)
Western Melbourne			**2016**			**2017**			**2018**			**2019**	
1	>89		20 (2.5)	5 (0.6)		44 (2.3)	11 (0.6)		46 (2.1)	13 (0.6)		66 (2.8)	10 (0.4)
2	60-89		95 (11.9)	16 (2.0)		177 (9.4)	32 (1.7)		209 (9.6)	33 (1.5)		222 (9.5)	40 (1.7)
3a	45-59	172 (21.5)	59 (7.4)	7 (0.9)	316 (16.7)	119 (6.3)	19 (1.0)	454 (20.9)	161 (7.4)	41 (1.9)	514 (21.9)	203 (8.7)	46 (2.0)
3b	30-44	78 (9.8)	37 (4.6)	15 (1.9)	154 (8.1)	63 (3.3)	32 (1.7)	235 (10.8)	113 (5.2)	51 (2.4)	285 (12.2)	137 (5.9)	54 (2.3)
4	15-29	12 (1.5)	10 (1.3)	7 (0.9)	19 (1.0)	17 (0.9)	22 (1.2)	36 (1.7)	46 (2.1)	36 (1.7)	47 (2.0)	57 (2.4)	46 (2.0)
5	<15 or dialysis	6 (0.8)	19 (2.4)	10 (1.3)	277 (14.6)	173 (9.1)	63 (3.3)	115 (5.3)	85 (3.9)	37 (1.7)	38 (1.6)	45 (1.9)	37 (1.6)
Tasmania			**2016**			**2017**			**2018**			**2019**	
1	>89		787 (10.0)	182 (2.3)		801 (9.4)	206 (2.4)		855 (9.5)	209 (2.3)		941 (9.8)	207 (2.2)
2	60-89		915 (11.7)	204 (2.6)		1002 (11.8)	206 (2.4)		1018 (11.3)	211 (2.3)		1118 (11.6)	216 (2.2)
3a	45-59	2316 (29.6)	640 (8.2)	212 (2.7)	2532 (29.8)	693 (8.2)	228 (2.7)	2701 (29.9)	750 (8.3)	224 (2.5)	2915 (30.3)	775 (8.1)	240 (2.5)
3b	30-44	955 (12.2)	515 (6.6)	230 (2.9)	1048 (12.3)	569 (6.7)	248 (2.9)	1116 (12.4)	605 (6.7)	267 (3.0)	1196 (12.4)	664 (6.9)	270 (2.8)
4	15-29	244 (3.1)	292 (3.7)	230 (2.9)	285 (3.4)	309 (3.6)	224 (2.6)	324 (3.6)	319 (3.5)	249 (2.8)	319 (3.3)	333 (3.5)	255 (2.7)
5	<15 or dialysis	28 (0.4)	41 (0.5)	45 (0.6)	31 (0.4)	45 (0.5)	61 (0.7)	38 (0.4)	49 (0.5)	84 (0.9)	40 (0.4)	49 (0.5)	83 (0.9)

NB: Percentages do not equal 100% as data in white squares not included

urine Albuminuria (uACR) categories (mg/mmol): **Normal**= Male: <2.5 Female: <3.5; **Micro**= Male: 2.5-25 Female: 3.5-35; **Macro**= Male: >25 Female: >35

We assessed monitoring between 2016 to 2019 against the recommendations for each Clinical Action Plan. However, management could only be assessed where data was available. All datasets contained glycaemic results, TKC and Western Melbourne datasets contained blood pressure results and only Western Melbourne dataset held prescription of ACE inhibitors or ARBs data.

Further, the numbers presented in the following tables for the Tasmanian dataset do not reflect the numbers presented in the heat map in Table 4 as care for each Clinical Action Plan has been assessed against eGFR CKD staging. That is, yellow action plan corresponded to CKD stages 1, 2 and 3a; orange action plan with CKD stage 3b, and red action plan with CKD stages 4 and 5. This is because the low levels of uACR in the data set, did not allow for meaningful analysis.

3.3.3 Care against Yellow Clinical Action Plan

In this section, we examine alignment for those in the earliest stages of CKD, with or without microalbuminuria, to the Yellow Clinical Action Plan. We assessed the proportion of individuals who received recommended monitoring, i.e. uACR, eGFR, blood pressure and HbA1c test (for people with diabetes), completed every 12 months. We also assessed the proportion of people who achieved their blood pressure and glycaemic control targets and, in the case of the Western Melbourne dataset, those who were prescribed ACE or ARB medications.

3.3.3.1 Monitoring – TKC dataset

Table 5 presents the annual eGFR and uACR testing trends among the Yellow Clinical Action Plan in the TKC dataset from 2016 to 2019. The data reveals an increase in eligible candidates from 5506 in 2016 to 7965 in 2019 along with an observed increase in the percentage of individuals who did not receive any tests (0% to 14%). The number of participants receiving only eGFR testing remained relatively constant and low (3% to 5%) as did uACR only tests. The proportion of individuals who received both eGFR and uACR tests were high initially but decreased from 98% in 2016 to 80% in 2019, possibly reflecting the inclusion of new datasets into TKC as new health services joined.

Annual monitoring of HbA1c for diabetics was consistently high, around 91% to 93%. Blood pressure testing also maintained a steady adherence rate of 92–96%.

These high testing rates in the early stages of CKD reflect selection bias. TKC only includes individuals that either have a diagnosis for CKD or are included because they have been screened and found to meet the criteria for inclusion. Screening for entry into TKC also includes risk factors of hypertension and diabetes, which may also identify uncoded cases of CKD.

Table 5: Monitoring according to Yellow Clinical Action Plan for TKC dataset

Conditions	2016 N=5506	2017 N=6496	2018 N=7388	2019 N=7965
No test, n (%)	0 (0)	552 (9)	988 (13)	1145 (14)
eGFR Only, n (%)	0 (0)	219 (3)	338 (5)	410 (5)
uACR Only, n (%)	97 (2)	64 (1)	58 (0.8)	40 (0.5)
Both tests, n (%)	5409 (98)	5661 (87)	6004 (81)	6370 (80)
Diabetics, N	**2496**	**2834**	**3178**	**3446**
HbA1c annual, n (%)	2333 (93)	2630 (93)	2936 (92)	3145 (91)
BP check, N	**5506**	**6496**	**7388**	**7965**
Yes, annual n (%)	5305 (96)	6167 (95)	6884 (93)	7336 (92)

3.3.3.2 Monitoring – Western Melbourne dataset

In the Western Melbourne dataset, a significant increase was observed in the percentage of individuals who did not receive any tests, from 18% in 2016 to 46% in 2019, while the percentage of individuals who were monitored decreased from 63% in 2016 to 39% in 2019 (Table 6). For those with diabetes, the percentage of individuals who had an annual HbA1c test increased from 69% in 2016 to 92% in 2017, decreasing to 60% in 2019. As noted earlier, the fall in monitoring may be due to the transition of the 2017 cohort into a different management category. There was also an increase in the percentage of individuals undergoing annual blood pressure checks from 37% in 2016 to 64% in 2019 (Table 6).

Table 6: Monitoring according to Yellow Clinical Action Plan for Western Melbourne dataset

Conditions	2016 N=287	2017 N =537	2018 N =709	2019 N =802
No test, n (%)	52 (18)	129 (24)	230 (32)	372 (46)
eGFR Only, n (%)	52 (18)	78 (15)	103 (15)	105 (13)
uACR Only, n (%)	2 (0.69)	8 (1)	17 (2)	11 (1)
Both tests, n (%)	181 (63)	322 (60)	359 (51)	314 (39)
Diabetes, N	**77**	**177**	**235**	**269**
HbA1c annual, n (%)	53 (69)	163 (92)	136 (58)	162 (60)
BP check, N	**287**	**537**	**709**	**802**
Yes, annual n (%)	105 (37)	420 (78)	412 (58)	516 (64)

3.3.3.3 Monitoring – Tasmanian dataset

As noted earlier, due to the low presence of uACR in the Tasmanian dataset, the monitoring analysis has focussed on CKD staging by eGFR only. Over the study period, there was a slight increase in monitoring with annual testing rates for eGFR and uACR rising. Although, by 2019, only 24.6% had been tested with 17.4% receiving no tests. However, annual HbA1c testing rates for diabetics consistently stayed above 80%. BP data was not available in the dataset (Table 7).

Table 7: Monitoring according to Yellow Clinical Action Plan for Tasmanian dataset

Tests	2016 N = 16,207	2017 N = 16,414	2018 N = 16,419	2019 N = 16,663
No test, n (%)	3,535 (21.8)	3,173 (19.3)	3,061 (18.6)	2,900 (17.4)
eGFR Only, n (%)	9,204 (56.8)	9,516 (58.0)	9,528 (58.0)	9,665 (58.0)
uACR Only, n (%)	12 (0.1)	12 (0.1)	0 (0)	0 (0)
Both tests, n (%)	3,456 (21.3)	3,713 (22.6)	3,830 (23.3)	4,098 (24.6)
Diabetes, N	4080	4198	4243	4301
HbA1c annual, n (%)	2894 (70.9)	3056 (72.8)	3093 (72.9)	3208 (74.6)
BP check	NA	NA	NA	NA

3.3.3.4 Management

We investigated the number of individuals who received a BP check, and, of those, the percentage who attained the recommended BP target of less than 140/90 mmHg or less than 130/80 mmHg for diabetics. We also assessed the number of diabetics who had an annual HbA1c test and the proportion to attain a glycaemic target of less than 7%. In the Western Melbourne dataset, we were also able to assess the prescribing of recommended antihypertensives such as ACEi or ARB and statins (Table 8).

The percentage of individuals achieving target blood pressure levels in the TKC dataset remained relatively constant (91–92%) despite an overall increase in the number of individuals in the dataset. Similarly, the percentage of diabetics to achieve HBA1c levels of less than 7% remained steady at approximately 50%. No data on prescriptions of ACEi/ARBs or statins were available in the TKC dataset.

In the Western Melbourne dataset, the proportion of individuals who had a BP check and attained a BP target of ≤ 140/90 was high and varied between 92–95%. Conversely, for diabetics who had an annual HbA1c, there was a downward trend in annual glycaemic control attainment from 64% in 2016 to 56% in 2019. Regarding medications, the prescription rates for ACE inhibitors or ARBs increased, peaking at 60% in 2017. Statin prescriptions increased from 11% in 2016 to 45% in 2019.

The Tasmanian dataset only contained HbA1c results, with around 58–59% of diabetics who had a test achieving the target for annual glycaemic control of less than 7%.

Table 8: Management according to Yellow Clinical Action Plan for TKC, Western Melbourne and Tasmanian datasets

Year	2016	2017	2018	2019
TKC N	**5506**	**6496**	**7388**	**7965**
BP taken, n	5305	6167	6884	7336
<140/90 Yes, n (%)	4898 (92)	5695 (92)	6326 (92)	6685 (91)
Diabetes, n	2496	2834	3178	3446
HbA1c taken	2333	2630	2936	3145
Glycaemic target <7%, n (%)	1160 (50)	1255 (48)	1434 (49)	1566 (50)
Prescription, n	NA	NA	NA	NA
Western Melbourne N	**287**	**537**	**709**	**802**
BP taken n	105	420	412	516
<140/90 Yes, n (%)	97 (92)	399 (95)	391 (95)	483 (94)
Diabetes, n	77	177	235	269
HbA1c taken	53	163	136	162
Glycaemic target <7%, n (%)	34 (64)	82(50)	80 (59)	90 (56)
Prescription, n	287	537	709	802
ACE/ARB, n (%)	39 (14)	321 (60)	295 (42)	415 (52)
Statin, n (%)	32 (11)	263 (49)	258 (36)	357 (45)
Tasmania N	**16,207**	**16,414**	**16,419**	**16,663**
BP taken, n	NA	NA	NA	NA
Diabetes, n	4,080	4,198	4,243	4,301
HbA1c taken	2,894	3,056	3,093	3,208
Glycaemic target <7%, n (%)	1,720 (59)	1,790 (59)	1,793 (58)	1,906 (59)
Prescription, N	NA	NA	NA	NA

3.3.4 Care against Orange Clinical Action Plan

This section examines the alignment with the Orange Clinical Action Plan and recommended monitoring of individuals, i.e. uACR, eGFR, lipids, blood pressure and HbA1c tests (for people with diabetes), completed every 3-6 months. We also examined the proportion of people who achieved their blood pressure targets, glycaemic control and were prescribed ACEi or ARB, and statins. Tables 9–11 present the results of six-monthly (i.e., at least 2 or more tests in 12 months) monitoring trends in the TKC, Western Melbourne and Tasmanian datasets.

3.3.4.1 Monitoring – TKC dataset

Within the TKC dataset (Table 9), there was a downward trend between 2016 to 2019 (99 to 85%, respectively) in the proportion of individuals meeting the criteria for the Orange Clinical Action Plan who received recommended monitoring. There was a small but significant corresponding increase in the percentage of individuals who received no test. The number of individuals who received 2 HbA1c tests in 12 months remained relatively high and constant, as did the proportion of individuals receiving 2 BP tests annually. As noted earlier, these high rates of adherence to monitoring are likely due to selection bias of the TKC cohort, as inclusion in TKC is based on the presence of some of these variables.

Table 9: Six-monthly monitoring according to Orange Clinical Action Plan for TKC dataset

Conditions	2016 N=318	2017 N=390	2018 N=462	2019 N=475
No test, n (%)	0 (0)	25 (6)	47 (10)	57 (12)
eGFR Only, n (%)	0 (0)	7 (2)	6 (1)	14 (3)
uACR Only, n (%)	1 (0.3)	1 (0.2)	1 (0.2)	0 (0)
Both tests, n (%)	317 (99)	357 (92)	408 (88)	404 (85)
BP check, N	**318**	**390**	**462**	**475**
BP six-monthly, n (%)	311 (98)	308 (79)	444 (96)	453 (95)
Diabetics, N	**196**	**209**	**287**	**311**
HbA1c six-monthly, n (%)	187 (95)	195 (93)	271 (94)	293 (94)

3.3.4.2 Monitoring – Western Melbourne dataset

In the Western Melbourne dataset, monitoring according to the recommendations in the Orange Clinical Action Plan appeared to decrease (60 to 35%), with a corresponding increase in the number of individuals without a test (14 to 44%) between 2016 and 2019. The proportion of individuals receiving the recommended 6 monthly BP check increased from 37% in 2016 to 62% in 2019. Although the actual number of individuals receiving 2 BP checks increased over the years of the study, this was not congruent with the increasing number of people requiring assessment.

Similarly, the number of diabetics in the dataset grew between 2016 and 2019, but the number of six-monthly tests did not increase accordingly. We assessed the number of diabetics that received at least one HbA1c test six-monthly and noted a downward trend with annual HbA1c tests falling from 70% in 2016 to 54% in 2019, although rates were much higher in 2017 (89%) and 2018 (64%) (Table 10).

Table 10 Six-monthly monitoring according to Orange Clinical Action Plan for Western Melbourne dataset

Conditions	2016 N=174	2017 N = 336	2018 N = 509	2019 N = 625
No test, n (%)	24 (14)	74 (22)	147 (29)	275 (44)
eGFR Only, n (%)	43 (25)	76 (23)	114 (22)	129 (21)
uACR Only, n (%)	2 (1)	9 (3)	10 (2)	5 (1)
Both tests, n (%)	105 (60)	177 (53)	238 (47)	216 (35)
BP check, N	174	336	509	625
BP six-monthly, n (%)	64 (37)	265 (79)	347 (68)	385 (62)
Diabetes, N	79	152	224	274
HbA1c six-monthly, n (%)	55 (70)	136 (89)	143 (64)	147 (54)

3.3.4.3 Monitoring – Tasmanian dataset

In the Tasmanian dataset (Table 11), the percentage of individuals monitored 3-6 monthly remained constant and low over the study period at less than 10%. This is not surprising given the low evidence of uACR in the dataset. HbA1c testing remained consistent throughout the study period, with approximately 40% of diabetics receiving six-monthly HbA1c checks and over 80% having at least one test per 12-month period.

Table 11: Six-monthly monitoring according to Orange Clinical Action Plan for Tasmanian dataset

	2016 N = 6,430	2017 N = 6,624	2018 N = 6,686	2019 N = 6,814
No test, n (%)	3,575 (56)	3,657 (55)	3,539 (53)	3,513 (52)
eGFR Only, n (%)	2,431 (38)	2,518 (38)	2,676 (40)	2,750 (40)
uACR Only, n (%)	0 (0)	0 (0)	0 (0)	0 (0)
Both tests, n (%)	424 (7)	449 (7)	471 (7)	551 (8)
Diabetics, N	2085	2205	2231	2283
HbA1c six-monthly, n (%)	919 (44)	969 (44)	951 (43)	932 (41)
At least 1 HbA1c annually, n (%)	1836 (88)	1834 (83)	1890 (85)	1795 (79)

3.3.4.4 Management

Table 12 presents the attainment of targets for patients meeting the criteria for the Orange Clinical Action Plan from 2016 to 2019 for the three datasets.

In the TKC dataset, the percentage of individuals who had a six-monthly BP check achieving a blood pressure target of less than 140/90 remained relatively constant and high, with over 90% of individuals attaining a recommended BP target. The percentage of individuals who had a six-monthly HbA1c achieving glycaemic control of less than 7% remained relatively stable at approximately 60%.

In the Western Melbourne dataset, the percentage of individuals who had a BP check and achieved BP target of <140/90 was also high and maintained above 90% over the study years. Attainment of glycaemic targets were lower and averaged 55% over the study years for those who had a six-monthly HbA1c. With medication prescription of ACEi/ARBs and statins, there was a sharp and dramatic improvement from 2016 to 2017 and then a gradual deterioration of results between 2017 to 2019.

In the Tasmanian dataset, for those who had a HbA1c six-monthly, glycaemic control was achieved by approximately 30–37% of individuals over the study period. For those who only had an annual check, 49–56% attained target HbA1c. There was no data available for BP attainment or medication prescribing.

Table 12: Six-monthly management according to Orange Clinical Action Plan for TKC, Western Melbourne and Tasmanian datasets

Year	2016	2017	2018	2019
TKC N	**318**	**390**	**462**	**475**
BP taken six-monthly, N	311	308	444	453
<140/90, n (%)	289 (93)	290 (94)	413 (93)	422 (93)
Diabetes, N	196	209	287	311
HbA1c tested six-monthly	187	195	271	293
six-monthly Glycaemic target <7%, n (%)	118 (63)	116 (59)	159 (59)	179 (61)
Prescription, N	NA	NA	NA	NA
Western Melbourne N	**174**	**336**	**509**	**625**
BP taken six-monthly, N	64	265	347	385
<140/90, n (%)	62 (97)	259 (98)	323 (93)	361(94)
Diabetes, N	79	152	224	274
HbA1c tested six-monthly	55	136	143	147
six-monthly Glycaemic target <7%, n (%)	32 (58)	72 (53)	75 (52)	84 (57)
Prescription, N	174	336	509	625
ACE/ARB, n (%)	21 (12)	221 (66)	282 (55)	324 (52)
Statin, n (%)	20 (12)	194 (58)	246 (48)	285 (46)
Tasmania N	**6430**	**6624**	**6686**	**6814**
BP taken, N	NA	NA	NA	NA
Diabetes, N	2085	2205	2231	2283
HbA1c tested six-monthly	919	969	951	932
six-monthly Glycaemic target <7%, n (%)	311 (34)	342 (35)	351 (37)	278 (30)
HbA1c tested annually	1836	1834	1890	1795
Annual Glycaemic target <7%, n (%)	989 (54)	1009 (55)	1055 (56)	871 (49)
Prescription, N	NA	NA	NA	NA

3.3.5 Care against Red Clinical Action Plan

In this section, we analysed the frequency of quarterly testing (1–3 monthly) for individuals who met the criteria for the Red Clinical Action Plan across the three datasets. Additionally, we assessed the percentage of people who achieved targets for blood pressure and glycaemic control, as well as prescriptions for ACEi, ARB and statins. Tables 13–15 summarise the testing trends and outcomes over the study period.

3.3.5.1 Monitoring – TKC dataset

In TKC, the number of individuals in the Red Clinical Action Plan increased yearly, from 2763 in 2016 to 3769 in 2019, while monitoring decreased from a high of 99% in 2016 to 85% in 2019. The percentage of individuals who did not receive an eGFR or uACR slightly increased from 0% in 2016 to 11% in 2019. A high percentage of individuals had at least one BP test done quarterly, and this remained stable at approximately 92–96%. Similarly, the percentage of individuals who had at least 2

HbA1c tests each quarter remained relatively high at 92–95% over the study period (Table 13). As mentioned earlier, these results likely reflect selection bias within the TKC cohort.

Table 13: Quarterly monitoring according to Red Clinical Action Plan for TKC dataset

Conditions	2016 N=2763	2017 N=3231	2018 N=3559	2019 N=3769
No test, n (%)	0 (0)	146 (5)	325 (9)	417 (11)
eGFR Only, n (%)	0 (0)	84 (3)	121 (3)	139 (4)
uACR Only, n (%)	17 (0.6)	13 (0.4)	13 (0.4)	7 (0.2)
Both tests, n (%)	2746 (99)	2988 (92)	3100 (87)	3206 (85)
Diabetics, N	**1939**	**2255**	**2517**	**2664**
HbA1c quarterly, n (%)	1847 (95)	2120 (94)	2328 (92)	2461 (92)
BP check, N	**2763**	**3231**	**3559**	**3769**
BP quarterly, n (%)	2662 (96)	3060 (95)	3306 (93)	3460 (92)

3.3.5.2 Monitoring – Western Melbourne dataset

Our analysis of Western Melbourne found a decrease in the numbers of individuals meeting the criteria for the Red Clinical Action Plan from a high of 665 in 2017 to 420 in 2019. We noted the percentage of individuals receiving quarterly monitoring were low in the middle years at below 20%. Higher rates of monitoring in 2016 and 2019 (61% and 32%, respectively) may be related to the methodology (Table 14). For diabetes management, quarterly HbA1c testing demonstrated a downward trend from 87% in 2017 to 51% in 2019. There was little evidence of quarterly BP checks, but, similar to HbA1c checks, there was a downward trend in annual BP checks for this group from 92% in 2017 to 54% in 2019.

Table 14 Quarterly monitoring according to Red Clinical Action Plan for Western Melbourne dataset

	2016 N = 107	2017 N = 665	2018 N = 493	2019 N = 420
No test, n (%)	21 (20)	281 (42)	388 (79)	221 (53)
eGFR Only, n (%)	19 (18)	273 (41)	58 (12)	63 (15)
uACR Only, n (%)	2 (2)	9 (1)	12 (2)	1 (0.2)
Both tests, n (%)	65 (61)	102 (15)	35 (7)	135 (32)
Diabetics, N	51	315	244	222
HbA1c quarterly, n (%)	41 (80)	275 (87)	153 (63)	114 (51)
BP check, N	107	665	493	420
BP quarterly, n (%)	0 (0)	15 (2)	2 (0.4)	0 (0)
BP annually, n (%)	44 (41)	615 (92)	310 (63)	225 (54)

3.3.5.3 Monitoring – Tasmanian dataset

Similar to other analyses of the Tasmanian dataset, the evidence of quarterly monitoring as per the Red Clinical Action Plan was very low due to the negligible presence of uACR. Evidence of quarterly Hba1c checks was also low (at approximately 2%), however, annual HbA1c checks were around 82% for the entire study period.

Table 15 Quarterly monitoring according to Red Clinical Action Plan for Tasmanian dataset

Conditions	2016 N = 6428	2017 N = 6622	2018 N = 6682	2019 N = 6812
No test, n (%)	5,895 (83.6)	6,028 (82.7)	5,991 (80.5)	6,124 (80.2)
eGFR Only, n (%)	440 (13.5)	487 (14.2)	603 (17.0)	603 (17.4)
uACR Only, n (%)	0 (0)	0 (0)	0 (0)	0 (0)
Both tests, n (%)	93 (2.9)	107 (3.1)	88 (2.5)	85 (2.4)
Diabetics, N	1,403	1,519	1,594	1,616
HbA1c quarterly, n (%)	30 (2.1)	31 (2.1)	35 (2.2)	36 (2.2)
HbA1c annually, n (%)	1151 (82)	1238 (81.5)	1324 (83.1)	1321 (81.7)

3.3.5.4 Management

Table 16 presents data on care against recommendations for patients meeting the criteria for the Red Clinical Action Plan across the three datasets.

The total number of individuals receiving a quarterly blood pressure check in the TKC dataset increased from 2,662 in 2016 to 3,460 in 2019, but the percentage achieving the blood pressure target declined from 90% to 86% over the same period. Of the diabetics who received three-monthly HbA1c checks, approximately 46% attained the recommended target of less than 7%.

In the Western Melbourne dataset, a very low percentage of people received a quarterly BP check, so we assessed target attainment against an annual BP check. A high percentage of those who received an annual BP check attained the target BP <140/90, decreasing slightly from 95% in 2016 to 91% in 2019. Of those who had a quarterly HbA1c, approximately 50% attained glycaemic control. Regarding medications, ACEi or ARBs were prescribed to 73% of individuals in 2017, decreasing to 42% in 2019. The prescription rates for statins also declined from 65% in 2017 to 40% in 2019.

Due to the low number of quarterly HbA1c checks in the Tasmanian dataset, we assessed attainment of HbA1c targets against annual testing. Approximately 40% of individuals that had an annual HbA1c met the recommended target of less than 7%.

Table 16 Quarterly management according to Red Clinical Action Plan for TKC, Western Melbourne and Tasmanian datasets

Year	2016	2017	2018	2019
TKC N	**2763**	**3231**	**3559**	**3769**
BP taken quarterly, N	2662	3060	3306	3460
Quarterly BP <140/90, n (%)	2383 (90)	2696 (88)	2882 (87)	298 (86)
Diabetes, N	1939	2255	2517	2664
HbA1c tested quarterly	1847	2120	2328	2461
quarterly Glycaemic target <7%, n (%)	789 (42)	979 (46)	1081 (46)	1150 (47)
Prescription, N	NA	NA	NA	NA
Western Melbourne N	107	**665**	**493**	**420**
BP taken, N	44	615	310	225
annual BP <140/90, n (%)	42 (95)	576 (94)	294 (95)	205 (91)
Diabetes, N	51	315	244	222
HbA1c tested quarterly	**41**	**275**	**153**	**114**
three-monthly Glycaemic target <7%, n (%)	22 (54)	144 (52)	72 (47)	60 (53)
Prescription, N	107	665	493	420
ACE/ARB, n (%)	16 (15)	483 (73)	272 (55)	175 (42)
Statin, n (%)	11 (10)	435 (65)	260 (53)	168 (40)
Tasmania N				
BP taken, N	NA	NA	NA	NA
Diabetes, N	1,403	1,519	1,594	1,616
HbA1c tested annually	1,151	1,238	1,324	1,321
Annual Glycaemic target <7%, n (%)	492 (43)	533 (43)	575 (43)	596 (45)
Prescription, N	NA	NA	NA	NA

3.4 Discussion

It is clear from this component of the analysis that comparisons between the datasets are problematic given the very different derivations and purposes of each dataset. The TKC dataset appears to demonstrate high levels of screening and monitoring particularly in the early years, but this is likely due to selection bias of the TKC cohort, MBS incentives for Adult Health Check and a strong adherence to local guidelines developed for remote area services. A downward trend was also noted in some of the analyses around monitoring and target attainment and this may reflect additional health services joining the program and additional patients entering the TKC system.

The Western Melbourne dataset frequently displayed a pattern of sharp improvements in the second year of the study and then a downward trend to the end of the study. This may be due to the data time frame, which only collected data from 2017 and early 2018 with 2 years of retrospective data for the cohort and followed through to 2019. Screening and monitoring rates would have been affected by the denominator of each group as patients progressed to the next stage. Lower levels of monitoring may also reflect a lowering of support for implementation and uptake of the clinical decision support tool within partnering health services, noted in the interviews.

The Tasmanian dataset was difficult to analyse for this component given the low levels of uACR, absence of blood pressures and medications in the dataset.

However, all three datasets demonstrated difficulties with diabetes monitoring and attaining recommended target levels with results consistently sitting around 50%.

3.5 Limitations and Challenges

Data limitations included:

1. The TKC dataset is a subset of the population and inclusion criteria includes risk factors for CKD, such as diabetes and hypertension. In order to be admitted to the dataset, an individual would have received screening. Therefore, there is a selection bias with this dataset which would account for the very high rates of adherence to screening and monitoring.
2. The Western Melbourne dataset only contained data from primary healthcare systems and from a select group of participating health services. Cohort recruitment was for a limited period from 2017 to early 2018 resulting in the denominator being smaller prior to the commencement of recruitment. Additionally only coded data was used in the identification of at-risk conditions and CKD. This may not have captured all results that contribute to the identification of at-risk conditions used in the previous analysis.
3. The diagnosis of at-risk conditions for the Tasmanian dataset are likely to be under-reported as only individuals with hospital admission data were included. Thus hypertension, cardiovascular disease and obesity were identified based on the presence of ICD codes. As ICPC codes used in primary health care settings were not available, the true burden of chronic disease may be under-reported in this dataset. For the same reasons, the prevalence of CKD may also be under-reported in our analysis.
4. Definitions of at-risk conditions varied across the three datasets (Table 1), which might explain the variable prevalence of at-risk conditions in each study population. Some misclassifications in yearly CKD stages, especially for Western Melbourne and Tasmania, were possible, with both higher and lower CKD stages present in the same year based on eGFR and/or uACR results. In this case, usually higher CKD stages were considered.

Challenges

The project team were based in Darwin, Northern Territory, which presented challenges in accessing and analysing the Western Melbourne and Tasmanian dasets. In particular, it was time consuming and resource intensive to gain approval from multiple levels within the respective organisations in Melbourne and Hobart to meet data security protocols, ethics and governance frameworks.

Additionally, data from these sites were unable to be shared with the Darwin project team and processes to establish remote access on partner government servers were required, as were negotiations to provide appropriate analytical programs on those servers. This took considerable coordination between each institutions' IT managers and their third-party vendors.

Further, server capacity/speed was an issue, while stability of the remote access connection was a frustration and an impediment to workflows, particualry with the large size of the datasets. The inability to host the data on a local server and the restricted access has also limited the team's ability to undertake repeat analysis or have multiple team members analysing the data.

4 Chapter 4 – Barriers and enablers to the uptake of clinical decision support systems

KEY POINTS

1. Functional aspects of digital systems can be both a barrier and an enabler to the uptake of clinical decision support (CDS). Systems that are user-friendly, visually interesting and provide consolidated patient data have greater uptake.

2. Increase in presentations of patients with complex conditions highlight the need for CDS to address multimorbidity, rather than a single condition

3. Training, 'at elbow' support and well-communicated implementation plans are key strategies for successful uptake of CDS while ongoing training and accessible post implementation support are crucial to the longevity and sustainability of CDS.

4. Clinical workloads, time constraints and remuneration pressures are barriers to CDS uptake, while demonstrated cost-effectiveness will facilitate uptake

The following section considers evaluation work undertaken alongside this project and includes findings from research into the uptake of clinical decision support (CDS) systems, including the implementation of electronic health records (EHR) in clinical settings. For the purposes of this study, primary health care providers were GPs, nurses and practice managers in general practice, working in the public, private and Aboriginal Community Controlled sectors. Clinicians based in the tertiary sector were also consulted.

4.1 Objective

The objective of this component was to evaluate the barriers and enablers to the implementation of initiatives that harness the power of existing electronic medical record data, such as decision support and report feedback tools. The particular systems we evaluated were: TKC, an integrated data platform in the Northern Territory; CD-IMPACT, a clinical decision support system in Western Melbourne, Victoria; and, the data linkage project CKD.TASLink in Tasmania.

4.2 Methodology

Interviews with key stakeholders in the Northern Territory, Victoria and Tasmania were undertaken. Interviews were coded by two researchers to identify emerging themes and reviewed by a third researcher to validate interpretations and findings. Emerging themes were compared and consolidated to highlight the key issues, outlined in the following section.

The overall aim of the interviews was to understand how the digital systems in each jurisdiction were being utilised to support clinical decision making in relation to the identification and management of CKD. The intent was not to make a direct comparison of the three digital systems, as their purpose, design, functions and context differed, and thus it was not possible to make direct comparisons. Instead, this component sought to explore the barriers and enablers to the implementation and uptake of digital and data linkage systems and the opportunities within these contexts to inform policy and practice.

4.3 What is known

A systematic review of clinical decision support (CDS) systems and the barriers and facilitators to uptake was conducted. The review found that chronic disease CDS designs are often single-disease focused and rarely incorporate sufficient EHR data to be applicable in multimorbidity (19). A focus on alerts and reminders was found in more than 80% of user interfaces, and this was associated with alert fatigue with most clinicians ignoring or overriding the alert. The uptake of CDS were dependent on several factors, including:

- the clinical context and/or disease condition
- user experience and value add
- external or organisational factors, and
- technical issues, such as system intuitiveness, responsiveness, training and support.

Additionally, most CDS were narrow in focus, did not access or utilise sufficient EHR data to provide comprehensive management decisions (holistic approach to multimorbidity) and often required additional manual data entry.

The user interface was critical to uptake, but the systematic review noted that many CDS had not evolved beyond alerts and reminders, which were not only a barrier to uptake but contributed to clinician burnout. Resourcing beyond the project implementation phase was a key barrier to uptake, namely the inadequate resourcing of the CDS project team to provide ongoing training and drive clinician engagement. Improvement in health-related outcomes tended to plateau post-implementation (often funded through short-term competitive research grants) with the removal of ongoing support. In one study, the research team also sought to have the CDS included as an MBS item to improve and sustain uptake but were informed that MBS items cannot be attached to software (28).

The clinical and technological expectations of users are changing and, in this highly digitised era, there are expectations that EHR data should not only be immediately integrated within CDS systems, but applications must be attractive, easy to use and contain all the desired functionality to assist the user. Users want CDS applications to address the five rights: right information, to the right person, in the right format, at the right time and through the right channel (29). However, this has proven difficult with guidelines (particularly guidelines for digital content) focusing on a single condition or disease that are more appropriate for the acute setting, e.g. stroke or heart attack. There is a lack of CDS in the primary health sector that adequately addresses the increasing complexity and multimorbidity of patients who present to GPs. An ideal chronic disease CDS system for primary health would be wide rather than narrow in clinical scope but this would require clinical collaboration across disciplines as well as with vendors and developers to ensure standards of interoperability are adhered to and algorithms reflect the complexity of clinician workflows (19).

For a variety of reasons, but largely due to funding requirements, hospitals have for many years collected clinical information using International Classification of Diseases (ICD) coding. However, EHRs utilised by most general practices in primary health have historically had a low reliance on coded information, with most data entered by clinicians as text. In recent years, there has been a surge in the use of codes, such as International Classification of Primary Care (ICPC) codes in primary health EHRs, to improve the collection and understanding of conditions and disease burden in the primary health sector. Additionally, CDS systems, designed to support GPs with complex decision making, typically rely on coded data for the efficient application of decision-making algorithms. Coded data can also be more effectively aggregated and analysed for reporting purposes.

Thus, there is an impetus in primary health to improve data collection and understanding through the greater utilisation of ICPC coding.

4.4 Findings

Interviews were conducted across the three jurisdictions and included primary and tertiary-based specialists and clinicians, policymakers and researchers. The CD-IMPACT project had a geographic focus on the Western Health catchment area of Victoria, while TKC focussed on a subset of the population that had chronic disease in the NT and CKD.TASlink had a whole of state focus. The professional status of interviewees differed in each state according to the intent and purpose of the digital system. For instance, in the NT, participants included nephrologists, GPs, nurses and allied health staff; while in Victoria, the focus was on GPs, nurses and practice managers, although nephrologists were also interviewed; and in Tasmania, those interviewed included nephrologists, GPs, nurses, policymakers and researchers. Twenty-nine interviews were conducted for this component.

Four main themes arose from the interviews:

1. Implementation – change practice and culture
    a. TKC – Northern Territory
    b. CD-IMPACT – Victoria
    c. CKD.TASlink – Tasmania
2. Quality improvement and evidence-based care
3. Resourcing as a barrier to the implementation of evidence-based care
4. Translating outcomes into policy and practice

4.5 Key Themes

4.5.1 Implementation – changing practice and culture

a. ***TKC – Northern Territory***

The TKC initiative was designed as an adjunct to an EHR used in primary and tertiary clinical settings. It does not replace current systems in the primary or tertiary health sector nor require users to enter data. In addition to providing immediate summation of longitudinal data from multiple sources, TKC can also be used as a communication tool for sharing readily prepared patient summaries with other clinicians. TKC is accessible through a web-based portal. The initial barriers to engagement with the initiative from health services included concerns over the consent model, data sovereignty and purpose of sharing clinical information, data security, storage and access. These were addressed in a legally prepared Data Participation Agreement, which was signed by each participating health service's CEO (13) and endorsed by NT Health.

At the time of the interviews, TKC had moved into the live environment but was still experiencing teething problems with duplication of information, incomplete patient identifiers or diagnosis based on incorrect data entry at the source system. Additionally, as the system was hosted on NT Health infrastructure, non-government clinicians could only access the system through a complicated layer of screens and authentications (involving 16 mouse clicks). This created frustration, irritation and a barrier to uptake. At this early implementation stage, some clinicians could not envisage the value

that TKC could add to their practice. As one non-government GP noted *'I can't see what is being offered is worth the effort to get into the system'* [Email feedback].

Data quality issues were addressed through the 'Feedback' function within TKC, which along with the quick responses, provided a welcome feature that supported data validation and cleaning and enhanced data quality within primary health services. External access to the system was re-designed to bring the authentication layers down to four mouse clicks – making the system far more accessible for many users.

Overall, TKC received positive feedback from users for its ease of navigation, with one consultant describing TKC as a '*valuable asset for clinic interactions*' [TKC05]. Users were also impressed with the graphs that could track the management of renal function, BP, glucose levels and stages of CKD. *'This is a great tool to use when speaking to patients as a picture means so much more to them than words'* [Email feedback]. Interview participants indicated that TKC was useful for clinicians at the coalface due to its ability to pull information from different platforms and consolidate patient data in one place. The inclusion of data on other comorbidities and the visual presentation of blood results, medication lists and recommended treatment plans made it highly beneficial for all clinicians. *'I am impressed with the trajectory of the CKD which is formulated in the graphs so that's very helpful for us as a clinician to know'* [TKC01]. Although TKC was initially designed for CKD management by primary care and nephrology services, an increase in TKC usage by other tertiary areas, including Intensive Care Unit, Peri-Operative Care and the Emergency Department, was observed.

Other popular functions included the ability to send correspondence and access locally-appropriate educational material for patients. The level of uptake depended on the user specialty and need, with some functions going unnoticed or rarely used. This indicated a need to maximise usage by regularly updating users on the current and new functions available in TKC and developing role-specific training materials.

b. ***CD-IMPACT – Western Melbourne***

The CD-IMPACT project involved an extension to the EHR used in participating general practices and changes to data entry practices for clinicians. The customised software enabled GPs to use their own practice's data to perform clinical audits and monitoring. Hardcopy benchmarking reports were generated by the CD-IMPACT research team using data extracts provided to them by the practice, enabling comparisons against their own and other practices' performance over time. In terms of implementation, some participants commented on the labour-intensive nature associated with entering clinical codes and explained that patients' information from specialists/clinicians contained in PDF files could be missed as their data could not be extracted by the tool.

The benefits of the system were also highly dependent on the accuracy of coding and data entry. Historically, in many practices, diagnosis and clinical information was entered as text, and staff who were used to this way of working were reluctant to improve coding as many did not see the benefits of population health analysis. *'If things weren't coded properly then you weren't pulling out the correct data. There's a few [staff] who are quite resistant to coding, but that made it a bit more difficult'* [Int 3 Vic].

Some participants commented that GPs were reluctant to code CKD in a patient file with one suggesting it was akin to providing a diagnosis of cancer. This was interpreted as a reluctance to 'label' a patient as having kidney disease related to assumptions and stigma associated with chronic conditions. However, clinicians could see the benefits of integrating the CD-IMPACT system into business-as-usual to enable greater awareness of the need to identify and manage CKD in earlier

stages, thereby improving knowledge of evidence-based screening activities and management of concomitant conditions.

The uptake of CD-IMPACT varied across practices and was often associated with the culture of the practice. Participants noted that the landscape of private practice was vastly different from government services as each practice operated independently. Further, although CD-IMPACT was recognised as a way to improve clinical systems, it required a change management process.

Reluctance to implement CD-IMPACT was associated with an assumption that the system might result in unsolicited recalls, creating an additional responsibility for practices to manage. Interview participants acknowledged that implementation required a coordinated team approach and leadership from the top and that resistance was likely to come from those who did not understand the benefits or saw the process as complicated or time consuming. This is likely to be contextual and related to a number of factors including: stability of patient population, how well the GP knows their patients, longevity of a GP in the practice and longevity of practice ownership. *'If they kind of think "well I'm doing okay, well you know I'm doing that with my patients, I know what I'm doing", it can be a bit resistant to change how to do things'* [Int 3 Vic].

Interview participants noted that 'medical centres' were less likely to get involved in quality improvement projects like CD-IMPACT due to time constraints. Others believed changes were more likely to occur in clinics that were not GP-owned and where practice managers made decisions about quality improvement activities. GPs employed by a practice, instead of being contracted, were also more likely to embrace the changes through early induction and training. Participants suggested that using champions and sharing good news stories about the benefits of the system would support change and uptake: *'…if one or two [GPs] start …. they say oh, hey, I actually found this and that and whatever. It just goes through word of mouth across the practice then everyone will start'* [Int 1 Vic].

c. CKD.TASlink – Tasmania

The CKD.TASlink is a retrospective cohort study that was designed to identify geographic and gender inequities in screening for CKD. It used linked data from five health and two pathology datasets from Tasmania (16). The CKD.TASlink report was compiled and generated by the University of Tasmania and disseminated to stakeholders. Interviewees of the CKD Consortium project noted that they were unaware of the analysis until receiving the report and had limited direct involvement in the design, scope of analysis or interpretation of the data in the report. However, participants recognised the value and usefulness of analysis generated from data linkage exercises to identify the burden of disease, demonstrate service demand and support advocacy measures.

Interviewees acknowledged that the CKD.TASlink report provided a comprehensive analysis, made possible by data linkage. However, a limitation of data linkage was that it could not be shared in real time between service providers due to a lack of appropriate data-sharing arrangements. This lack of real-time sharing of clinical information for patient care was perceived as a barrier to implementing changes in practice, with one participant commenting, '...*we've got a very clunky system here.… We have got a digital core medical record, but that's just the scanned record, which means it can't be shared with primary care'* [Int 6 Tas].

Participants fully agreed with the findings in the report, seeing it as *'… a very true reflection of the actual state of affairs*' [Int 5 Tas]. However, participants noted that while a lot of data had been collected and analysed, there was no clear path as to how the data was going to be used to improve clinical outcomes, change clinical practice or advocate for resources. Participants questioned how the report findings could be translated into practice, while others felt that the lessons learnt from the report findings had not found traction amongst GPs, despite the report being used in various

contexts, including presentations to other clinicians. Based on the perceived limitations of the report, interview participants expressed uncertainty about the report's impact on clinical practice in Tasmania, *'I suspect it hasn't had a lot of penetration with GPs'* [Int 2 Tas].

Nonetheless, participants acknowledged that the report provided valuable information about kidney health across the whole of Tasmania, with a level of granularity that enabled the report to be used in:

- presentations
- supporting cases for change in service development
- reinforcing suspected regional variation of the burden of disease, and
- providing insights into best practice management.

4.5.2 Quality improvement and evidence-based care

In the NT, Victoria and Tasmania, the respective projects were seen as opportunities for establishing quality improvement processes that supported evidence-based care. In the NT, TKC enhanced care practices by providing practitioners with comprehensive data on their patients, with one interview participant commenting, *'TKC helps us to know straight away where the patient's CKD is heading towards and what other encounters they had over the last many years, [the] journey of a patient'* [Int 1 NT].

In particular, the three systems were successful in highlighting the prevalence of certain conditions amongst different demographics and the links between CKD and other conditions, with one GP commenting, '*We learned about the really strong tie between CKD and cardiovascular health and that's been informative for our clinicians'* [Int 5 Vic].

TKC's ability to pull information from multiple tertiary and primary health settings saved clinicians' time searching through individual records and helped reduce their workloads. TKC linked data from multiple associated systems, accurate record linkage and data cleaning optimised the functioning of the system. Feedback to participating health services (correcting misapplied ICPC codes or mis-entered patient identifiers) was identified as a 'valuable CQI [continuous quality improvement] activity' as it not only enhanced data quality but supported the education of clinicians to improve the use and application of ICPC coding. Users also noted that quality improvement and evidence-based care offered in TKC could be further enhanced by including more patient information so that *'it is all integrated in TKC'* [Int 5 NT] and getting more health providers to join TKC to increase the number of patients (and all interactions with health services) captured by the system across the Territory. This aim of 'one patient one record' was seen by many as necessary, particularly if evidence-based care was to be delivered by all clinicians and for all patients across the NT.

In Victoria, the CD-IMPACT project supported best practice activities including clinical investigations and the collection of the correct CKD diagnosis for patients leading to a pathway for early management. It helped raise clinician awareness of evidence-based testing, provided insights into causal links between conditions and promoted the implementation of guidelines. While interviewees recognised the intent of the system to provide benchmarks and set standards for measuring quality, participants commented that demonstrating the value of the project to patients and clinicians was necessary to support uptake. For example, one interviewee explained that no one in their practice was interested in using the tool until the impact of the tool in the workplace was demonstrated, which in turn led to changes in staff attitudes and the integration of quality improvement activities within the practice's processes. Further, regular clinical prompts were also considered useful for clinicians, with any unattended prompts presented at follow-up appointments. Others noted that

improvements in CKD screening and coding occurred after the project ended, indicating benefits were ongoing. Potential barriers to the uptake of CD-IMPACT included the educational or upskilling activities GPs were required to complete, which was considered outside of their scope of clinical practice.

The availability and accessibility to guidelines was also described as a potential barrier to the implementation of evidence-based care, with some noting the many clinical and therapeutic guidelines GPs are asked to consult. Participants suggested a condensed set of guidelines for the screening and management of metabolic chronic diseases.

In following guidelines, interviewees noted that the 'timely referral' of a patient to a specialist was not always a solution with long waitlists or patient reluctance to see another specialist doctor. Participants also acknowledged that GPs are often best placed to support and manage patients, but this required a network of support and flexibility in referral guidelines. Being able to manage primary care patients for longer through access to guidelines and clinical decision support tools would benefit patients. Additionally, it would give confidence and reassurance to GPs that they were providing evidence-based care.

4.5.3 Resourcing as a barrier to the implementation of evidence-based care

Overall, a theme throughout the interviews (across the three projects and jurisdictions) was a strong perception that the landscape in primary health was changing with GPs seeing more chronic and complex conditions in their practice but struggling to maintain a satisfactory level of resourcing to manage the demand. Nearly all interviewees commented on the difficulty in resourcing health services and attracting and retaining staff. Interviewees in both the NT and Tasmania felt that the lower socio-economic demographics of their population made the delivery and uptake of care particularly challenging. Not only were patients struggling to manage day-to-day, but this impacted their ability to engage with health services and improve their level of self-management. This was compounded in both jurisdictions by the lower level of access to GPs. Several participants commented on the difficulties in managing the differing presentations, such as those requiring acute intervention versus more chronic or administrative care. Few patients attended clinics for preventative health.

Participants in all jurisdictions noted these workforce pressures and burgeoning patient lists made the implementation and uptake of guideline-based care more difficult. However, most interviewees believed that, given the appropriate resources and support, guidelines would be implemented and followed, with one person commenting, '*if we have the manpower and the support there, then the guidelines stuff would be just … follow. It's just being able to do that'* [Int 2 Tas].

The mechanisms for resourcing primary health care were a recurring theme across all jurisdictions and were perceived by participants as integral to the uptake of evidence-based guidelines. Some participants perceived the medicolegal aspects associated with billing for activities related to guideline implementation as unclear (i.e. what screening activities could be claimed) and were concerned about being flagged in the system for overbilling. However, most participants felt that Medicare reimbursements were inadequate for the volume of complex conditions presented to primary health practices. GPs often felt they were unable to provide their patients with adequate time to review all their complaints each time they presented.

Other resourcing challenges faced by primary care practices included:

1. inadequate number of GPs to see the volume of patients presenting
2. time constraints to complete investigations
3. reimbursement fee not commensurate with activities
    I. cost of the session to GPs due to low reimbursement fees, and to patients with complex conditions who require longer consultations
    II. lack of incentives for GPs to complete investigations, and
    III. concerns regarding being flagged by Medicare for overbilling.

Additionally, for some GPs, being involved in quality improvement activities, including implementation of guidelines, was not seen as a priority against other competing demands for their time – '... *there's no compensation for [using the system] and so when it comes down to it ...you know doctors do have to make those tough choices sometimes of where they spend their time'* [Int 5 Vic].

In Tasmania, the implementation of guidelines was seen by some to be more successful if the practice was supported with a Practice Nurse or a CKD nurse, noting that GPs were extremely busy and had competing priorities. For some, guideline implementation was seen as the responsibility of the nurses within the practice, who were primarily in charge of chronic disease patient management plans and ensured that screening and other relevant tests were completed, with one interviewee noting '*…[the] practice nurses… they're the ones that are really doing the management plans and the chronic disease management'* [Int 2 Tas].

4.5.4 Impact of COVID-19

Participants noted that the COVID-19 pandemic had resulted in fewer patients presenting for routine appointments, reducing opportunistic discussions on kidney or heart health checks. This was both patient-driven (fear of going out or burdening busy doctors with routine requests), practice-driven (cancelling non-urgent clinics) and influenced by lockdowns, notably in Victoria. The lack of attendance meant patients were also unlikely to receive the required medication. This was especially pertinent to the lower socio-economic areas across all jurisdictions.

Consequently, many practices now find themselves overwhelmed with appointments for patients who require complex care due to the absence of a medical review in the previous 18–24 months (at the time of interview). For nephrology services, the cancellation of clinics lengthened referral times for specialist appointments. Contact continued with video appointments for a small proportion of patients, but many missed appointments with GPs and specialist services. Those patients now need more attention and management, although specialists believed they had not yet experienced the peak in presentations, with one participant commenting *'...I think we'll see in the years to come probably a little bit of a spike in the number of patients missing dialysis, treatments or things like that because of COVID....'* [Int 5 Tas].

4.5.5 Structural and systematic challenges

While chronic conditions, including the interrelated conditions of CKD, diabetes and cardiovascular disease, account for high mortality and morbidity (30), structural barriers to equitable healthcare are impacting on the diagnosis and management of such conditions. Australia's health system offers both publicly-funded health services and privately-funded services based on user choice (31). While significant funding has been allocated to support the planning, coordination and management of chronic conditions in primary care, access to publicly-funded primary health services has become

increasingly difficult in recent years for a large proportion of the population. Many GP practices no longer offer bulk-billing services and a high number of GP practices closed last year due to dwindling costs and workforce shortages (https://cleanbill.com.au/2024/01/cleanbill-blue-report-2024.) Further, the decreasing number of GP services offering bulk-billing and increasing out of pocket costs for patients saw a doubling in the number of people not visiting a GP due to cost in the last financial year, to 7% (nearly 1.2 million people) https://www.abs.gov.au/statistics/health/health-services/patient-experiences/2022-23. It is unsurprising, then, that Australia's primary care system is only able to provide half of the guideline-recommended care for many chronic conditions, and the number of potentially preventable hospital admissions across Australia remains high (32).

Intertwined with this was the consensus from our interviews that primary health had been, and continued to be, underfunded and that, regardless of technological advances, without an adequate workforce, patient care and service delivery could not improve. Some participants considered that the significant difficulty regional and remote areas had in attracting and retaining GPs was underestimated and more needed to be done in this area.

4.6 Translating outcomes into policy and practice

Australia's National Digital Health Strategy (2022–2028) has a vision for an inclusive, sustainable and healthier future for all Australians through a connected and digitally enabled health system (33). Digital technologies and data are seen as the key to overcoming healthcare challenges such as equitable access, chronic disease management and prevention and the increasing costs of healthcare. The four change enablers in the strategy are:

i. Policy and regulatory settings that cultivate digital health adoption, use and innovation

ii. Secure, fit for purpose and connected digital solutions

iii. A digitally ready and enabled health and wellbeing workforce, and

iv. Informed, confident consumers and carers with strong digital health literacy.

Enhancing the use of integrated clinical systems enables informed decision making, providing people better access to their health information when and where they need it, improved quality of care, and personalised health outcomes.

The strategies all aim to support regulatory changes, the evidence that sharing patient clinical information across health services can decrease preventable hospital admissions by improving communication and coordination between healthcare providers (34, 35). The NT, Victoria, and Tasmania all have digital health strategies that focus on connected systems, improved access to data for monitoring and reporting, and increased digital literacy of the workforce and patients to provide patient-centric care (36-38).

Service providers and clinicians also understand the need to better integrate care (39) and not just with sharing of information. There needs to be a move away from a disease focus and the management of separate conditions in isolation (40). Patients have long advocated for holistic care, particularly those with complex conditions who want systems of care that support their GPs and reduce the number of specialists they see (specialist fatigue) (41).

Linking and integrating patient health data across different systems and health services is essential for providing comprehensive, quality and safe care, but is also necessary if services are to provide cost-effective clinical care. In an environment of limited funding, increasing demand and workforce shortages, effective digital infrastructure and connected clinical information systems can support

population health measures, identify gaps in the quality and accessibility of primary health care, improve the understanding of resource demand, and inform policy and resource allocation.

While there are strategies focusing on these system improvements at the national and state level, there appeared to be little knowledge of these approaches among our interviewees. Interviewees emphasised the need for integrated clinical information and convenient, helpful reporting, which required further government lobbying, with one participant noting that *'… it's actually the policymakers and the bureaucrats that we have to convince* [Int 4 Tas].

Participants in the NT and Tasmania were hopeful that their respective systems would be used to understand the geographical burden of CKD, which would then inform population-level service planning and advocate for appropriate resourcing, '*...that will give us an opportunity to tell...government...how to plan for dialysis services and things like that*' [Int 5 NT].

4.7 Discussion

This study evaluates the barriers and enablers to implementing digital systems in the NT, Victoria and Tasmania. The main findings of the study are aligned with key findings from the systematic review.

a) Functional aspects of CDS to make them attractive and user friendly – no additional data entry

The CKD Consortium study found that functional aspects of digital systems can be both a barrier and an enabler to uptake of CDS. Participants were generally positive about using digital systems that were user-friendly, visually interesting and provided consolidated patient data. For example, TKC's ease of navigation, visual presentation of blood results and data on other comorbidities made the CDS highly beneficial for clinicians. Conversely, a key barrier for participants was the time-consuming nature of accessing the system in the first place. In Victoria, additional data collection was an issue, with participants complaining that entering clinical codes for CD-IMPACT was labour-intensive. The challenges around data entry were compounded by the fact that some health information contained in PDF files could not be extracted by the system's tool. These findings are consistent with the systematic review, which noted that reliance on manual data entry and lack of system integration were barriers to uptake, while the attractive use of visuals and colours, readily available patient information, including historical data, and user-friendly systems were enablers to uptake (19). These findings were not relevant to CKD.TASlink as a data linkage exercise. The findings from this study indicate that making CDS systems attractive and user-friendly and reducing data entry requirements can facilitate uptake.

b) Need for CDS systems to be designed to address multimorbidity

In interviews, participants commented on the growing number of patients with complex cases within the health system, particularly after COVID-19. Their comments highlight the need for CDS to effectively manage multimorbidity, rather than a single condition. Systematic reviews have found that despite decades of CDS research, many recent CDS interventions have remained limited in scope and were usually single-disease focused (18, 42). Additionally, these reviews showed that CDS systems rarely incorporated enough EHR data to be applicable in multimorbidity and utilised relatively simple or straightforward technological decision support. TKC and CD–IMPACT are examples of digital systems that focus on the management of risk factors for cohorts at risk or with CKD. The systems are unable to tailor care according to an individual's risk factors and management plans. This study highlights the multifaceted nature of chronic condition management and the need for intelligent systems to design complex clinical decision advice to support patient-centric care.

c) Training and support post-implementation to ensure continued use and uptake

Training and 'at elbow' support are key strategies when implementing new clinical information systems with the requirement for detailed and well-communicated training plans disseminated before go-live dates. The length of the training and support post-implementation will vary according to the size and complexity of the system, but usually include a transition plan to business-as-usual support mechanisms, such as the organisation's Helpdesk. However, our research has highlighted that the post-implementation period is crucial, and that ongoing training and support are required to ensure the longevity of uptake and sustainability of the CDS.

This was evident with TKC, where there was a noticeable drop in the use of TKC by clinicians in services after the initial implementation. On the other hand, services that had ongoing funding for TKC Implementation Officers had greater use of the system overall. Even so, there was noticeable variation by profession with the ongoing uptake of the system across these services. There was good use of the system by nurses and allied health staff where the TKC Implementation Officer was a Chronic or Kidney Disease Nurse, but uptake by GPs as well as other clinical professions was best where the TKC Implementation Officer was a registrar.

This was reflected in Victoria where interviewees agreed that having someone proficient with the system based within the service made a difference, *'…I guess sometimes you know things work better if there's a champion within the practice who is kind of driving the course….'* [Int 3 Vic]. In addition, one participant found that leading by example helped promote uptake by other staff in the workplace. Clinical champions and allocating personnel who could operate the CDS systems and provide technical support as 'go to' staff, assisted with post-implementation uptake. GPs in Victoria noted that attending training sessions off-site or after hours was considered difficult and often a barrier to the uptake of training. In Tasmania, the implementation of guidelines was found to be more successful if a Practice Nurse or a CKD Nurse provided support.

These findings show the importance of having dedicated and visible positions in health services to provide ongoing training and support.

d) Incentives to use CDS

This study showed that time constraints and remuneration pressures were also barriers to CDS uptake. Clinicians, particularly those in private practice, had to see the cost-effectiveness of the CDS. Spending time learning the system, including duplicating or entering additional data, was weighed up against the immediate benefit of the system. Budgetary demands of private practices and time constraints led GPs (particularly for those who owned practices) to make decisions about how they engaged with CDS systems. The lack of financial incentives to use CDS systems is a recognised barrier to uptake. In the past, researchers tried unsuccessfully to include CDS use as a billable item on a fee-for-service schedule in Australia (28). This study's findings, coupled with those of the systematic review, support the need to create incentives to encourage the sustainable uptake of CDS systems by health providers.

5 Chapter 5 – Cost-effectiveness of CDS systems

KEY POINTS

1. Early diagnosis with appropriate evidence-based management is necessary to improve outcomes and decrease overall cost, which is more cost-effective than early diagnosis or management alone.

2. The findings of this study support calls for investment in CDS tools and partnerships to improve CKD outcomes, reduce the burden of CKD on patients and healthcare systems

In this chapter, we consider the evaluation work undertaken alongside this project and include findings from the modelling and analysis of the costs of CKD management in primary health and the cost-effectiveness of the implementation of the TKC CDS tool.

5.1 Objective

To study the cost-effectiveness of the implementation of CDS tools.

5.2 Methods

A systematic review of the cost-effectiveness of CDS interventions was conducted. The study evaluated 76 papers that examined the effectiveness and costs of CDS interventions for chronic diseases. Additionally, the cost-effectiveness of the TKC system was modelled by examining patients' primary health and hospital episodes of care in TKC over a five-year period. Cost data included the cost of the development, implementation and ongoing management of TKC; Medical Benefit Scheme (MBS) items; Pharmaceutical Benefit Scheme (PBS) items; and admission data based on Australian Refined Diagnosis Related Groups (AR DRG). Markov modelling was used to determine the cost-effectiveness of scenarios related to TKC use.

5.3 Findings

CDS systems are designed to improve healthcare delivery by enhancing decision making for clinicians with targeted clinical advice (43, 44). For chronic conditions, CDS systems can target the entire continuum of care, from screening to diagnosis, to treatment and follow-up. However, research has shown that the lack of sustainable funding and reimbursement strategies beyond the early stages of a CDS project are common barriers to effective uptake (18, 28, 45). Additionally, CDS systems require ongoing resourcing for continued development and the integration of CDS tools into routine clinical care. Given these financial considerations, funders are interested in the cost-effectiveness of CDS interventions (46), yet there are limited examples of economic evaluations of CDS interventions (47, 48).

In a systematic review of chronic disease CDS interventions, Chen et al. noted that CDS demonstrated small improvements to health or process outcomes, but the evidence of cost-effectiveness was not strong. In the review of 76 studies, the authors found that the cost-effectiveness of chronic disease CDS systems varied widely between USD$2,192 to USD$151,955 per QALY (quality-adjusted life year)

compared to usual care (18). There was wide variation in CDS tools analysed, but most centred on alerts and reminders, which have been the mainstay of CDS since the 1990s. The progress in the development of the user interface has been slow and seen by the authors as problematic for users – who complain about alert fatigue. Further, the studies contained little evidence of the effectiveness of CDS tools beyond 12 months. The authors noted that funding for CDS interventions tends to be small in comparison to drug or device trials, and this impacted the modelling methods used to estimate cost-effectiveness (18).

There were large variations in study results in the systematic review, chiefly due to the diverse nature of the technologies, real-world applications, and differing evaluation methodologies. There is a demonstrated requirement for future CDS evaluations to follow a more robust methodology and a need for greater transparency in the reporting of models, parameter differences and sources (e.g., trial-based, expert opinion). Additionally, a standard process for the reporting of CDS design characteristics and economic processes is required. This would assist decision makers with the interpretation of results and whether a CDS is cost-effective in real-life situations.

In a retrospective cohort study by Chen et al, the authors examined the cost of care of individuals with CKD in TKC who attended primary health services over a six-year period. Individuals who only had hospital episodes of care were excluded. The study shows that health care costs increase significantly as CKD progresses, with the annual health care cost ranging from $7,956 per person for people at risk of CKD, to $67,099 per person for people with CKD stage 5 (45).

Building on the findings of the retrospective cohort study, a third study by Chen et al. (2024) reviewed the cost-effectiveness of TKC as a CDS tool for early CKD diagnosis and management compared to usual care (46). From the TKC database, the study modelled a cohort of 23,195 people at risk of or with CKD who had primary health episodes of care. Due to the participating health services being mostly in rural and remote areas, the cohort was largely First Nations people (89%) who had a mean age of 42 years. A Markoff cohort model was developed based on 6 years of patient data and extrapolated to 15 years. This study investigated the benefit of the CDS against 3 scenarios:

1. CKD diagnosis only (scenario 1),
2. CKD management only (scenario 2), or
3. both diagnosis and management (scenario 3).

The study shows that CDS is most cost-effective in scenario 3 ($96,684 per patient avoiding kidney replacement therapy (KRT), $30,086 per patient avoiding death). While scenario 1 ($162,046 per patient avoiding KRT, $44,427 per patient) and scenario 2 ($1.2M per patient avoiding KRT, close to $1M per patient avoiding death) are less cost-effective. The findings indicate that early diagnosis with appropriate evidence-based management is necessary to improve outcomes and decrease overall cost, which is far more effective than early diagnosis or management alone.

The findings of this study support calls for investment in CDS tools and partnerships to improve CKD outcomes, reduce the burden of CKD on patients and healthcare systems.

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