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ORIGINAL ARTICLE

Documenting Cardiovascular-Kidney-Metabolic Risk and Disease Within an Aboriginal Cohort

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Aim Aboriginal and Torres Strait Islander people experience high burden of cardiovascular, kidney and metabolic conditions, often manifesting in multimorbidity and contributing to over one third of life expectancy differentials. This article explores cardiovascular-kidney-metabolic (CKM) health within an Aboriginal cohort by documenting the burden of early risk, disease and factors associated with disease progression.

Methods A prospective longitudinal cohort of 601 Aboriginal people living in Central Australia spanning 2008–2016 was utilised. Research was driven by and based on community priorities and partnerships. Baseline data included questionnaires, clinical assessments and primary health care data; follow-up outcomes were derived from primary care clinical review, administrative hospitalisation and mortality datasets.

Results Four percent of participants (mean: 41.3 years; 47% female) had no CKM risk factors (Stage 1 CKM Syndrome or greater) at baseline, 54.6% had established cardiovascular disease, chronic kidney disease, and/or diabetes mellitus. Greater presence of CKM disease and co/multimorbidity was associated with greater socioeconomic disadvantage. After adjusting for age, participants with co/multimorbidity were more likely to die during follow-up (hazard ratio [95% confidence interval]: 2.2 [1.1–4.3]) than participants without clinical disease at baseline. During a mean follow-up period of 6.8 years, 30.4% of participants living with no clinical disease at baseline developed at least one CKM condition, and 25% progressed to co/multimorbidity.

Conclusions This study reveals a higher prevalence of cardiovascular, kidney, and metabolic risk and disease than previously reported and compared to non-Indigenous counterparts. The health sector must recalibrate disease prevention, move beyond single-organ management and implement interdisciplinary care coordination to prevent expansion of inequities.

Keywords Cardiovascular-kidney-metabolic health • Australian Aboriginal and Torres Strait Islander Peoples • Multimorbidity • Health inequities

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Introduction

Collectively, cardiovascular, kidney and metabolic diseases account for 35 percent of the life expectancy differentials experienced by Aboriginal and Torres Strait Islander communities [1]. More than one in three Aboriginal and Torres Strait Islander people live with at least one of these conditions, and one in eight (13%) live with two or more of these conditions. For Aboriginal and Torres Strait Islander people living with cardiovascular disease (CVD), 46% have comorbid diabetes and/or chronic kidney disease (CKD) [2]. Higher burden is evident from young ages; for those aged 18–44 years, 19% of those living with CVD have comorbid diabetes and/or CKD, compared to 13% of non-Indigenous counterparts [2]. This multimorbidity profile of CVD, diabetes mellitus and CKD, particularly in younger people, is recognised as a key contributor of health differentials and premature mortality.

Multimorbidity has been found to be associated with increased all-cause mortality for Aboriginal and Torres Strait Islander people [3]. Multimorbidity introduces complexity to clinical care pathways and care coordination and reduces individuals' capacity to focus on holistic wellbeing, their self-determination in making health- and life-related decisions and the intensity of their treatment. It also limits employment opportunities and engagement within community [3–6]. Effective prevention and management of multimorbidity is therefore a priority at all stages of the care continuum. In primary care, early preventative measures have been identified to proactively manage risk following a diagnosis of CVD, CKD or diabetes including interdisciplinary care, intensive behavioural interventions and pharmacotherapy managing broad risk factors [7]. Within the tertiary sector, secondary prevention and care coordination are recommended to support management of multiple conditions [8].

Cardiovascular, kidney and metabolic diseases share common behavioural and clinical risk factors, such as central adiposity, hypertension, dyslipidaemia, hyperglycaemia, tobacco use, poor quality sleep and dietary intake, and physical inactivity, psychosocial stress and genetic factors. Many social determinants are recognised drivers of high metabolic risk, such as food insecurity, financial instability and physical inactivity. In Australia, these disparities are evident for Aboriginal and Torres Strait Islander people, and result from the complex interplay of intergenerational discrimination and segregation stemming from colonisation and inequitable health system responses [7,9].

There is limited understanding of the natural history of, progression to, and link between these conditions. The conceptualisation of cardiovascular-kidney-metabolic (CKM) syndrome, defined as a "systemic disorder characterised by pathophysiological interactions among metabolic risk factors, CKD, and the cardiovascular system, leading to multiorgan dysfunction" [7], demonstrates an increasing focus on the pathophysiological interrelatedness of these conditions, most importantly as a guide to enhanced provision of evidence-based care.

Despite the increased awareness of the impact of multimorbidity among Aboriginal and Torres Strait Islander people, research and clinical care often focuses on secondary prevention following a diagnosis of diabetes, given its prevalence of up to 33% in some communities [10,11]. To our knowledge, CKM syndrome has not previously been explored in this population.

This article explores CKM health in a cohort of Aboriginal people living in Central Australia, by documenting the underlying burden of early CKM syndrome risk, established disease, and investigating progression and potential contributing factors.

Methods

The ENHANCeD (Exploring the Natural History of Adverse eNd-points in Cardiovascular disease and co-morbid Depression) study was a prospective longitudinal cohort study conducted in partnership with Aboriginal communities living in Central Australia between 2008–2016. The primary aim of ENHANCeD was to understand the relationship between social determinants, psychosocial health and cardiometabolic disease. Participants included 601 Aboriginal people aged 16–80 years at baseline.

Partnerships were developed between communities and the research team, with health and community organisations and senior Aboriginal leaders engaged in discussions and study codesign prior to community visits and individual consent and participation. Research was conducted in accordance with the Guidelines for ethical conduct in Aboriginal and Torres Strait Islander research [12,13].

Participants (n=608) were recruited across two original baseline studies, HOTH (The Heart of the Heart) study and the MHM (Men, Hearts and Minds) study [14,15], across Alice Springs township, town camps (Aboriginal fringe settlements) around Alice Springs (Northern Territory [NT], Australia), and six distinct remote communities within a 400 km radius. Central Australia makes up the southern region of the NT, and covers 570,000 km^2 [16]. Sampling in the HOTH study was representative of participating communities, and the MHM study involved opportunistic recruitment of men in participating communities. Participants were considered eligible at baseline if they were ≥16 years (≥18 years in HOTH), self-identified as Aboriginal and/or Torres Strait Islander, were residents of Central Australia (self-reported), and able to consent. For MHM, eligibility was restricted to men. Data were collated using a researcher-administered questionnaire and clinical assessment. Primary health care (PHC) records were reviewed to cross-check self-reported medical history.

Health record follow-up was undertaken in 2014–2016. Communities and relevant health and community services provided community approval, additionally MHM participants were re-consented for follow-up. HOTH participants consented to follow-up at baseline. Fourteen participants were enrolled in both studies with the earliest record kept;

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Table 1 Cohort characteristics at baseline, by CVD/CKD/DM disease status.

Characteristic	All participants	No clinical disease	Existing CVD/CKD/DM	p-value[a]
n	**601**	**273 (45.4)**	**328 (54.6)**	
Age, years	41.3 (14.3)	34.7 (12.5)	46.8 (13.3)	0.00
18–24	79 (13.1)	68 (24.9)	11 (3.4)	0.000
25–34	130 (21.6)	85 (31.1)	45 (13.7)	
35–44	162 (27.0)	64 (23.4)	98 (29.9)	
45–54	111 (18.5)	30 (11.0)	81 (24.7)	
55–64	80 (13.3)	23 (8.4)	57 (17.4)	
≥65	39 (6.5)	3 (1.1)	36 (11.0)	
Sex				
Female	281 (46.8)	95 (34.8)	186 (56.7)	0.000
Male	320 (53.2)	178 (65.2)	142 (43.3)	
Remoteness				
Alice Springs Township	147 (24.5)	82 (30.0)	65 (19.8)	0.015
Town camp	309 (51.4)	129 (47.3)	180 (54.9)	
Remote community	145 (24.1)	62 (21.7)	83 (25.3)	
Education				
No education	27 (4.5)	6 (2.2)	21 (6.4)	0.017
School ≤15 years	133 (22.1)	59 (21.6)	74 (22.6)	
School >15 years	120 (20.0)	60 (22.0)	60 (18.3)	
Post-school training	305 (50.8)	145 (53.1)	160 (48.8)	
Not stated	16 (2.7)	3 (1.1)	13 (4.0)	
Income[b]				
$0-199	43 (7.2)	24 (8.8)	19 (5.8)	0.015
$200-399	217 (36.1)	83 (30.4)	134 (40.9)	
$400-599	130 (21.6)	66 (24.2)	64 (19.5)	
$600-799	56 (9.3)	27 (9.9)	29 (8.8)	
$800-999	24 (4.0)	10 (3.7)	14 (4.3)	
$1000 and over	106 (17.6)	57 (20.9)	49 (14.9)	
Not stated	25 (4.2)	6 (2.2)	19 (5.8)	
Financial strain (days income lasts of 14 days)				
0–3 days	248 (41.3)	111 (40.7)	137 (41.8)	0.139
4–7 days	130 (21.6)	65 (23.8)	65 (19.8)	
8–12 days	54 (9.0)	27 (9.9)	27 (8.2)	
13–14 days	118 (19.6)	55 (20.2)	63 (19.2)	
Not stated	51 (8.5)	15 (5.5)	36 (11.0)	
Employed				
No	295 (49.1)	109 (39.9)	186 (56.7)	0.000
Yes	288 (47.9)	160 (58.6)	128 (39.0)	
Not stated	18 (3.0)	4 (1.5)	14 (4.3)	
SES grade				
0 - Greater socioeconomic disadvantage	99 (16.5)	40 (14.7)	59 (18.0)	0.000
1	152 (25.3)	70 (25.6)	82 (25.0)	
2	144 (24.0)	80 (29.3)	64 (19.5)	
3 - Less socioeconomic disadvantage	84 (14.0)	50 (18.3)	34 (10.4)	
Not stated	122 (20.3)	33 (12.1)	89 (27.1)	
Behavioural				
Vegetables at least once a day				
No	226 (37.6)	92 (33.7)	134 (40.9)	0.000
Yes	197 (32.8)	68 (24.9)	129 (39.3)	
Not stated	178 (29.6)	113 (41.4)	65 (19.8)	

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Table 1. (continued).

Characteristic	All participants	No clinical disease	Existing CVD/CKD/DM	p-value[a]
Fruit at least once a day				
No	267 (44.4)	106 (38.8)	161 (49.1)	0.000
Yes	153 (25.5)	53 (19.4)	100 (30.5)	
Not stated	181 (30.1)	114 (41.8)	67 (20.4)	
Bush tucker[c] at least once a week				
No	227 (37.8)	83 (30.4)	114 (43.9)	0.000
Yes	151 (25.1)	61 (22.3)	90 (27.4)	
Not stated	223 (37.1)	129 (47.3)	94 (28.7)	
Take away less than once a week				
No	235 (39.1)	100 (36.6)	135 (41.2)	0.000
Yes	183 (30.4)	58 (21.3)	125 (38.1)	
Not stated	183 (30.4)	115 (42.1)	68 (20.7)	
Soft drink less than once a day				
No	102 (17.0)	47 (17.2)	55 (16.8)	0.000
Yes	320 (53.2)	112 (41.0)	208 (63.4)	
Not stated	179 (29.8)	114 (41.8)	65 (19.8)	
Smoking				
Never	257 (42.8)	83 (30.4)	174 (53.0)	0.000
Ex	64 (10.7)	30 (11.0)	34 (10.4)	
Current	280 (46.6)	160 (58.6)	120 (36.6)	
Risky alcohol consumption[d]				
No	270 (44.9)	92 (33.7)	178 (54.3)	0.000
Yes	315 (52.4)	178 (65.2)	137 (41.8)	
Not stated	16 (2.7)	3 (1.1)	13 (3.9)	
Clinical/Biomedical				
Depression[e]	102 (17.0)	43 (15.8)	59 (18.0)	0.467
BMI	29.5 (6.7)	27.9 (6.1)	30.8 (6.8)	0.000
Waist circumference, cm	97.0 (87.0, 108.0)	93.0 (83.0, 101.0)	101.0 (91.0, 112.5)	0.000
Waist-hip ratio	1.0 (0.1)	0.9 (0.1)	1.0 (0.1)	0.000
Systolic blood pressure, mmHg	127.3 (116.0, 140.5)	124.0 (114.0, 136.8)	130.0 (118.0, 145.0)	0.000
Total cholesterol, mmol/L	4.8 (1.2)	4.9 (1.1)	4.7 (1.2)	0.002
LDL, mmol/L	2.7 (1.0)	2.9 (0.9)	2.5 (1.0)	0.000
HDL, mmol/L	1.0 (0.8, 1.2)	1.0 (0.9, 1.2)	1.0 (0.8, 1.1)	0.000
Triglycerides, mmol/L	2.0 (1.4, 3.1)	1.9 (1.3, 2.7)	2.2 (1.6, 3.5)	0.000
Glucose, mmol/L	5.5 (4.6, 7.4)	4.9 (4.3, 5.5)	6.4 (5.1, 9.9)	0.000
HbA1c, %	6.0 (5.7, 7.0)	5.7 (5.5, 6.0)	6.7 (6.0, 8.7)	0.000
ACR, mg/mmol/L	1.9 (0.7, 8.5)	0.7 (04, 1.3)	5.1 (1.6, 22.4)	0.000
GFR, mL/min/1.73m^2	105.5 (90.9, 117.1)	113.5 (102.0, 121.5)	105.0 (87.8, 114.7)	0.000
hs-CRP	4.0 (2.0, 8.0)	3.0 (1.9, 6.3)	5.0 (2.1, 9.0)	0.000

Categorical values: n (%); Normally distributed continuous variables: mean (SD; Non-normally distributed continuous variables: median (IQR)).

[a]p-value is comparing those with CKD/CVD/DM to those without clinical disease.

[b]Average personal income per fortnight (AU$).

[c]Bush tucker describes traditional native foods, including foods sourced from plants and animals.

[d]≥5 drinks at one occasion.

[e]Depression was defined as a major depressive disorder; a record of PHC or hospitalisation for depression; or by a score of ≥10 for self-reported depressive symptoms over the last 2 weeks using an adapted PHQ-9 measure [19].

Abbreviations: BMI, body mass index; CVD, cardiovascular disease; CKD, chronic kidney disease; DM, diabetes mellitus; LDL, low-density lipids; HDL, high-density lipids; HbA1c, haemoglobin A1C; ACR, albumin: creatinine ratio; GFR, glomerular filtration rate; hs-CRP, high-sensitivity C-reactive protein, SD, standard deviation; IQR, interquartile range; PHC, primary health care.

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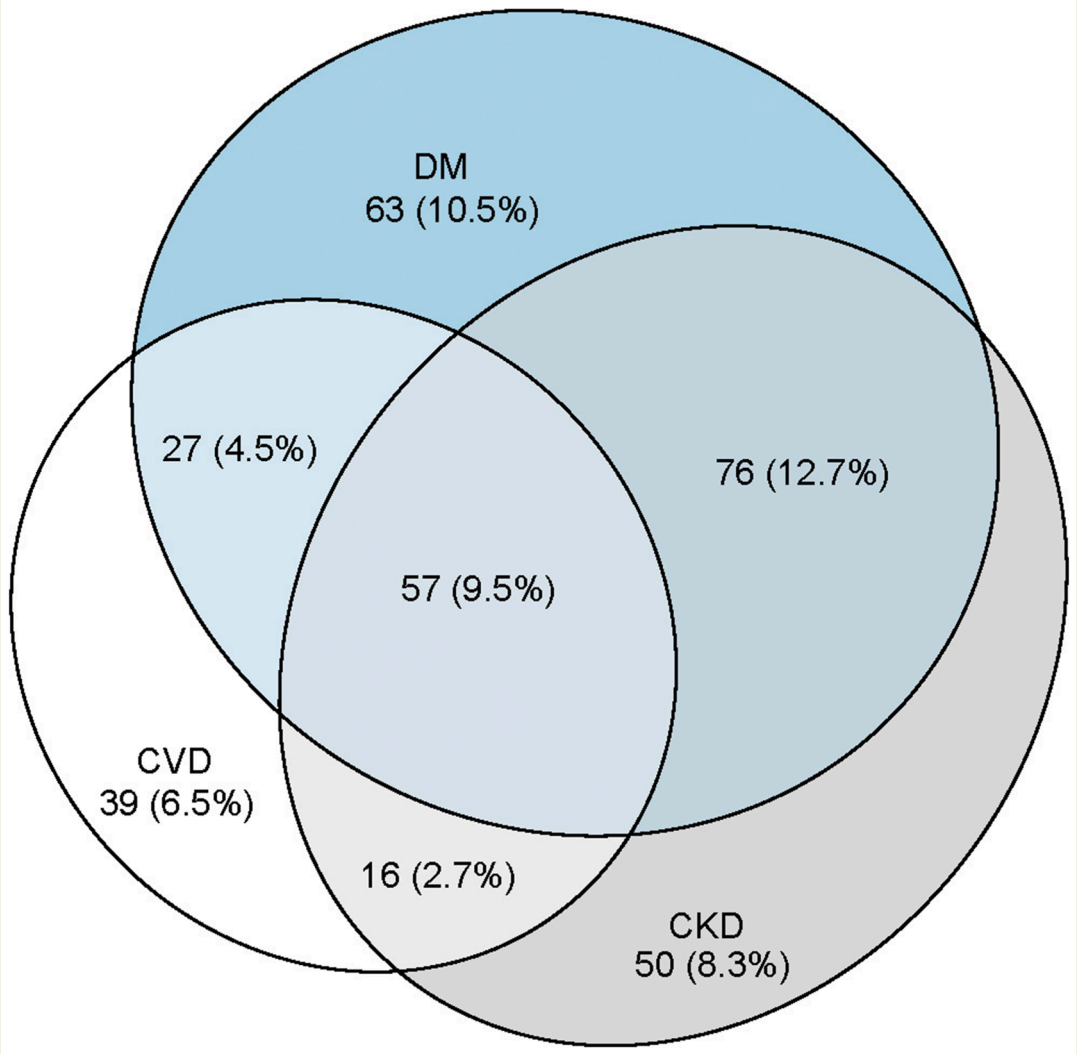

Figure 1 Number and proportion of participants with CVD, CKD, DM, comorbidity or multimorbidity at baseline (n=328). Abbreviations: CVD, cardiovascular disease; CKD, chronic kidney disease; DM, diabetes mellitus.

seven participants (1.2%) were lost to follow-up, leaving a total of 601 participants (see Supplementary Figure 1). Mean follow-up period was 6.8 years (standard deviation [SD]: 1.3 years). Health records accessed included patient information systems within PHC services, administrative patient records at Alice Springs Hospital, and from the National Death Index (https://www.aihw.gov.au/about-our-data/our-data-collections/national-death-index/about-national-death-index). Manual extraction was conducted with PHC data, automated extraction was undertaken for hospital and mortality data. PHC data was cross-referenced to hospital and mortality data to validate accuracy. PHC records seeking cause of death, hospitalisation and PHC diagnosis were adjudicated by a single investigator (A.D.H.B.) blinded to the baseline results of the individual participant. Data was censured at the date of data extraction from PHC, hospital or death registry records, whichever occurred first.

CKM syndrome is defined across four stages using the 2023 CKM health presidential advisory from the American Heart Association [7]. Stage 1 is defined as excess or dysfunctional adiposity, without other metabolic risk factors or established disease. Stage 1 or greater was defined for the cohort at baseline. Adiposity was determined by body mass index (BMI) ≥25 or waist circumference of ≥88 cm in women or ≥102 cm in men. Metabolic risk and CKM indicators were defined by fasting glucose of 5.6–6.9 mmol/L, glycated haemoglobin [HbA1c] of 5.7%–6.4%, hypertension (≥140/90 mmHg or medicated), triglycerides of ≥1.52 mmol/L, and the presence of metabolic syndrome [7]. CKM stages 2 to 4 were not defined for this cohort, instead disease status of CVD, CKD or diabetes was applied.

Self-reported, PHC record or hospital data were used to determine disease status at baseline for: CVD, as per diagnosis(es) for coronary heart disease (CHD), heart failure, cerebrovascular disease, or positive prior angiography,

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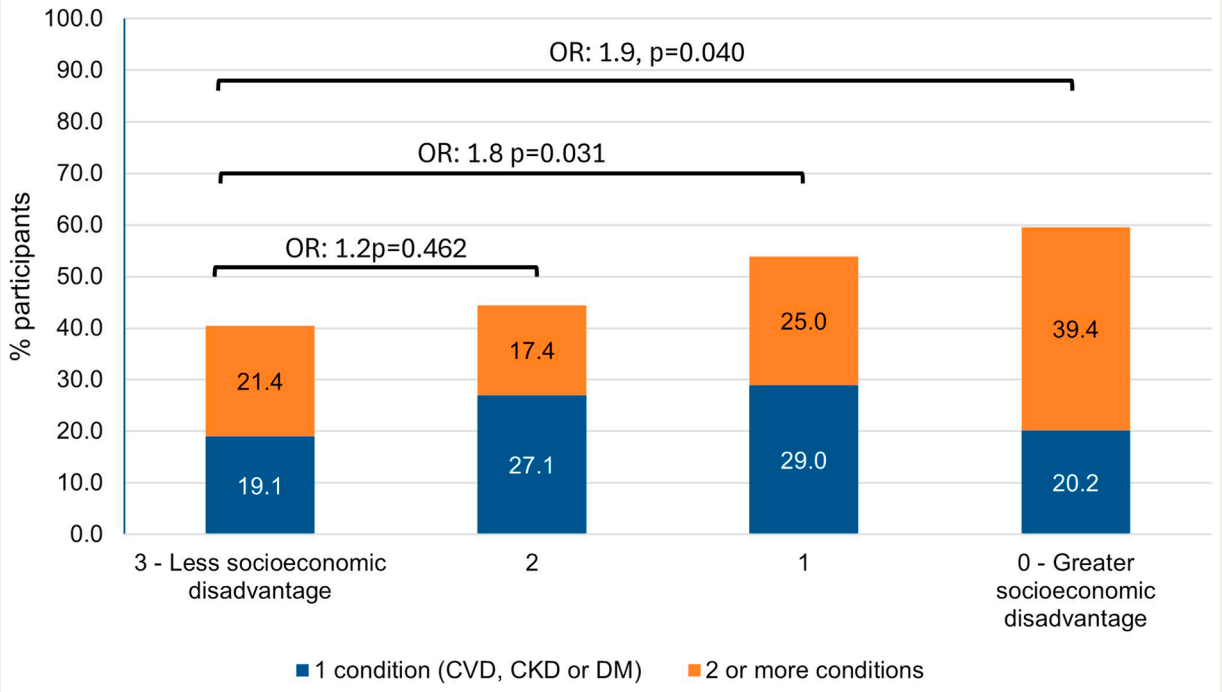

Figure 2 Existing CVD, CKD and/or DM at baseline by grade of socioeconomic disadvantage. Odds ratios for ordered logistic regression adjusted for age and sex.
Abbreviations: CVD, cardiovascular disease; CKD, chronic kidney disease; DM, diabetes mellitus; OR, odds ratio.

electrocardiogram (ECG) evidence of Q-waves or recognition of definitive angina on the Rose Angina Questionnaire; CKD, according to diagnosis of CKD, or by a calculated glomerular filtration rate (GFR) <60 mL/min/1.73 m^2, or evidence of microalbuminuria from a urinary albumin-creatinine ratio (ACR) test (ACR females: 3.5–35 mg/mmol; males 2.5–25 mg/mmol) with an eGFR 60–89 mL/min/1.73 m^2 [17]; or gestational or type 2 diabetes, diagnosis as per documentation, or by prescription of hypoglycaemic medications, or a HbA1c ≥6.5%.

Incident CVD was defined as hospitalisation or mortality for CHD, heart failure, cerebrovascular disease as identified in the National Death Index, hospital record or PHC record of hospitalisation, or a diagnosis within PHC records. Incident CKD was defined as a diagnosis in any of these datasets, or by a PHC documentation of ACR, GFR results (as above) [17]. Incident diabetes was defined as a diagnosis in the above datasets, or by new prescription of diabetes medications, or a PHC record of an oral glucose tolerance test during follow-up of ≥11.1 mmol/L at 2 hours or fasting plasma glucose of ≥7.0 mmol/L, in accordance with the American Diabetes Association diagnosis and classification [18].

Descriptive analyses were used to explore the demographic, socioeconomic, behavioural and clinical/biomedical characteristics of the cohort at baseline by presence of clinical disease, progression of incident disease, and mortality. Demographic measures include sex, age and place of residence. Socioeconomic measures include education, employment, income and financial strain (defined as having no money for 1 week out of the last two) [15]. A composite socioeconomic index (0–3) was developed, defined as the number of measures present: education over 15 years, income lasting at least 8 days in a fortnight (lower financial strain), and current employment. A higher score indicating less socioeconomic disadvantage. Behavioural measures include frequency of consumption of various food types, tobacco smoking status and risky alcohol consumption. Clinical and biomedical characteristics include depression based on the adapted PHQ9 tool [15,19], measures of obesity and central adiposity (BMI, waist circumference, waist-to-hip ratio), blood pressure, lipid profile, metabolic markers (HbA1c, glucose), kidney function (ACR, GFR) and inflammation (high-sensitivity C-reactive protein (hsCRP)). Categorical variables were expressed as numbers and percentages, normally distributed continuous variables as mean and SD, and non-normally distributed continuous variables as median and interquartile range (IQR). Between group differences were compared using the Pearson χ^2 test for categorical variables, t-test for normally distributed continuous variables, and the Mann–Whitney test for continuous, non-normally distributed variables. Ordered logistic regression analysis was undertaken to assess disease state across the grade of socioeconomic factors, adjusted for age and sex.

Survival analysis estimated Cox proportional hazard models predicting time to event for death for the entire

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cohort, and first incident event for those free of clinical disease at baseline. Breslow estimates baseline hazard function was applied. For first incident event, a first model explored demographic and socio-economic determinants and a second model added behavioural factors and biomarkers that were not used in diagnosis of incident disease. Only factors that were significant were kept as the model was constructed. Analyses were performed using Stata (Version 17.0, College Station, TX, USA) and eulerr [20], and significance was considered if $p<0.05$.

The studies on which the cohort was established were approved by the Central Australian Human Research Ethics Committee (ENHANCeD: HREC-14-274; MHM: 2007.09.05; HOTH: 2007.11.03). The ENHANCeD Study was approved by the Australian Institute of Health and Welfare Ethics Committee (EO2017/1/339) and the University of South Australia Human Research Ethics Committee (34687). HOTH was approved by Monash University Standing Committee on Ethics in Research Involving Humans, Victoria, Australia (CF08/0867 - 2008000250).

Results

The demographic, socioeconomic and behavioural determinants and clinical health profile of the cohort (overall and by baseline clinical disease status) are reported in Table 1. The mean age was 41.3 years (SD: 14.3 years), just under half were female (46.8%) and approximately one quarter lived in Alice Springs township, one quarter in remote communities, and half in town camps around Alice Springs.

Only 25 participants (4.2%) had no CKM risk factors at baseline (mean age 22.0 years, SD: 9.8 years). A further 41% of participants were at risk of CKM syndrome, with excess or dysfunctional adiposity (stage 1 or greater), but no clinical CVD, CKD or diabetes.

Despite the young age profile, over half of the cohort were living with clinical CVD, CKD or diabetes. Those with clinical disease were older, more likely female and people with no employment, and were less likely to reside in Alice Springs township. Those with clinical disease also had a higher BMI, waist circumference, systolic blood pressure, triglyceride, and hsCRP, and lower total cholesterol and low-density lipid profile. Those with clinical disease were more likely to respond to health behaviour questions (i.e., smaller proportion of not stated) except alcohol consumption. Over half of the cohort living with clinical disease had never smoked.

One in five (19.9%) people in the cohort were living with two conditions of CKM syndrome, and an additional 9.5% had multimorbidity of CVD, CKD and diabetes (Figure 1). Those who experienced greater socioeconomic disadvantage were more likely to be living with at least one condition, and more likely to be living with co/multimorbidity, after adjusting for age and sex (Figure 2).

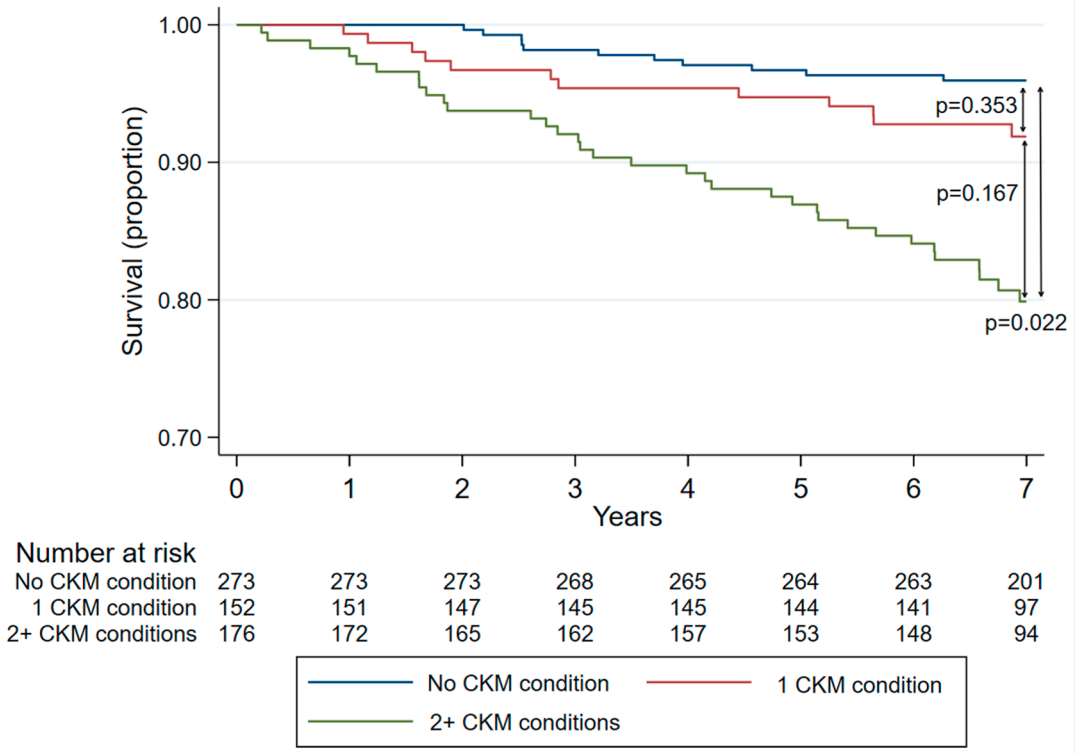

Figure 3 Survival curve - Time to death, by number of clinical diseases at baseline.
Abbreviation: CKM, cardiovascular-kidney-metabolic.

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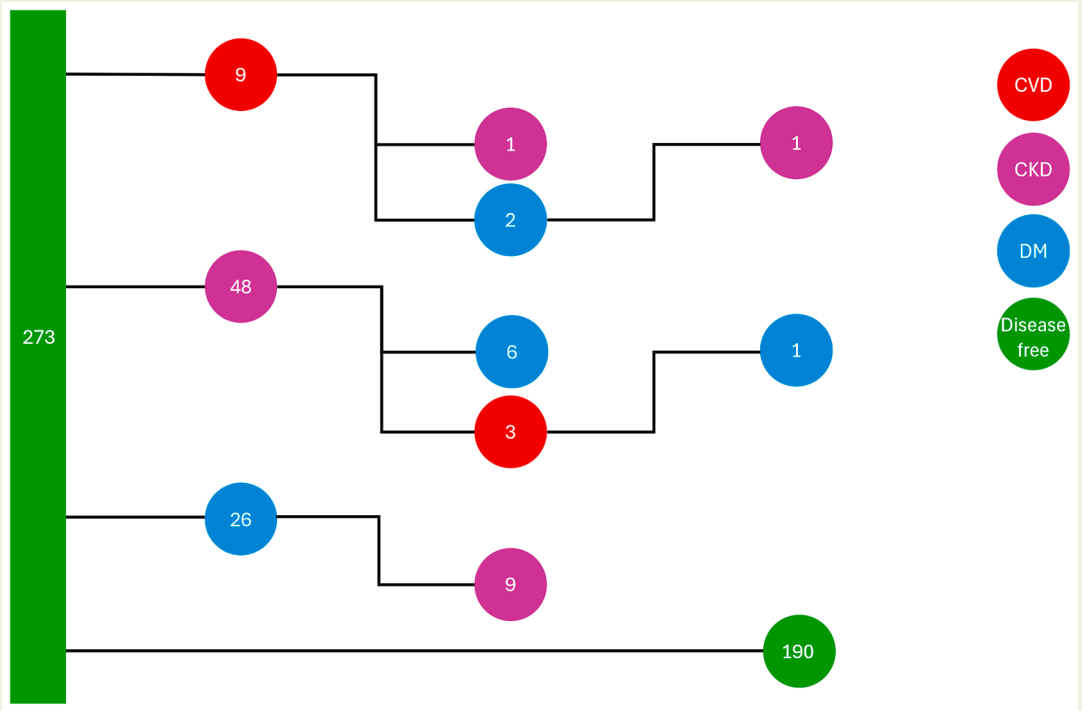

Figure 4 Progression of clinical disease across the 6.8 years of follow-up, for those with no disease at baseline. Abbreviations: CVD, cardiovascular disease; CKD, chronic kidney disease; DM, diabetes mellitus.

Mortality

During a mean follow-up period of 6.8 years (4,097 person-years), 64 (10.7%) participants died (Figure 3). After adjusting for age, people who had two or more conditions were more likely to die during follow-up (HR, 95% CI: 2.2, 1.1–4.3) compared to those who had no clinical disease at baseline.

Incident Disease

During a mean follow-up period of 6.8 years (1,653 person-years), 83 (30.4%) living with no clinical disease at baseline (mean: 34.7 years; SD: 12.5 years) developed at least one condition of CKM. Of those with incident disease, 48 (57.8%) experienced CKD onset first and 26 (31.3%) experienced diabetes onset first. A quarter (n=21, 25.3%) of participants with incident disease progressed to two or more conditions. Figure 4 shows progression of diagnoses. Only 12 (14.4%) developed CVD at any stage, compared to 35 (68.7%) who developed diabetes. All cases of CVD as a secondary condition were subsequent to first diagnosis of CKD.

Table 2 reports results of analyses exploring demographic and socioeconomic determinants of time to disease

Table 2 Adjusted hazard ratio and 95% CI for time to first event of incident CVD, CKD or diabetes (n=268; time at risk=1,605 person years) in a multivariate model.

	Model 1 (n=268; time at risk=1,605 years)	Model 2 (n=260; time at risk=1,576 years)
Age	1.02 (1.00, 1.04)	
Place of residence		
Alice Springs township	1 (Ref)	1 (Ref)
Town camp	2.51 (1.22, 5.17)	2.45 (1.17, 5.14)
Remote community	2.30 (1.19, 4.45)	2.32 (1.18, 4.58)
Employed at baseline	0.57 (0.36, 0.90)	0.61 (0.39, 0.97)
Waist-hip ratio	nd	16.35 (1.34, 199.88)
hs-CRP	nd	1.04 (1.01, 1.07)

Abbreviations: CI confidence interval; CVD, cardiovascular disease; CKD, chronic kidney disease; Ref: reference category; hs-CRP: high-sensitivity C-reactive protein; nd, not done as not part of Model 1.

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incidence (Supplementary Table 1 presents univariate results). Time to first diagnosed disease was positively associated with increasing age and residing in a town camp or in remote community, and inversely associated with employment at baseline. When considering association with behavioural factors and biomarkers, there was a positive significant association with increased waist-to-hip ratio and hs-CRP levels. With the inclusion of these biomarkers, age was no longer significant. There was no association identified with behavioural factors.

Discussion

This study demonstrates a very high burden of CKM risk and clinical disease in Aboriginal people living across communities in Central Australia. Over half of participants had established CVD, CKD or diabetes, and almost a third had co/multimorbid disease. This burden is higher than reported in the literature documenting the presence of CKM conditions within Aboriginal and Torres Strait Islander communities, and when compared to burden in the non-Indigenous population [2]. These results also highlight the development of CKM clinical diseases at young ages. The majority of the cohort had underlying CKM syndrome risk, demonstrating the importance of primary prevention, early screening, and aggressive, multiorgan management and care coordination when diagnosed with one condition.

Our findings are consistent with previous work by Randall and Lujic [3], with multimorbidity associated with increased all-cause mortality; this demonstrates specific relevance for CKM syndromes.

This is the first known time that CKM syndrome, a recently proposed disorder [7], has been described within Aboriginal and Torres Strait Islander communities. This study found that over 95% of participants had stage 1 CKM syndrome, excess or dysfunctional adiposity, and given the burden of co/multimorbidity, there was evident multiorgan dysfunction. Further research is required to explore this syndrome within Aboriginal and Torres Strait Islander populations, and other communities that experience disparities in CVD, which may contribute to a greater understanding of the pathophysiological interactions between metabolic diseases, CKD and CVD and the biological, social and environmental exposures or pressures that drive them. Interestingly, no behavioural factors (nutrition, smoking, risky alcohol consumption) were identified as significant contributors to incident CVD, CKD or diabetes in this study, whilst socioeconomic determinants were.

The findings demonstrate presence of greater burden for those with greater socioeconomic disadvantage. This relationship between socioeconomic disadvantage and prevalent disease has previously been evidenced within Aboriginal and Torres Strait Islander populations in the kidney [21] and diabetes [22] literature. These findings further indicate the role of social gradient as a likely driver of CKM risk within Aboriginal and Torres Strait Islander communities, as well as differences between populations due to discrimination and disadvantage [23].

The role of CKD in development of CVD cannot be underestimated in this population. In those free of clinical disease at baseline, CVD occurred subsequently to CKD but not diabetes, seemingly in contrast to well documented elevated risk of CVD in Aboriginal people with diabetes, particularly women [24]. Future research should seek to elucidate the drivers of rapid progression, in particular better ways of identifying those at greatest risk and exploring sex differences. We have identified waist-to-hip ratio as predictive of incident disease, not BMI. This echoes the body of literature that suggests central adiposity measures are more reliable markers of CVD and mortality over measures of obesity alone [25,26]. hsCRP was very strongly associated with incident disease. Elevated levels of inflammatory markers have been linked with CKM syndrome and associated conditions, including within Aboriginal and Torres Strait Islander populations [27,28]. Inflammation may be an important pathway connecting CKD and CVD, and requires further understanding, particularly in this population which has elevated levels [7].

The findings may be unique to Central Australia and thus may not be directly translatable across Aboriginal and Torres Strait Islander communities. Conduct of this study in Central Australia did enable very high rates of follow-up, due to the nature of the discrete health network with a single hospital within the region, and capture of PHC data across multiple services. The follow-up period within this study is relatively short, particularly when considering progression of chronic disease. The long-term progression of disease cannot be ascertained through this study. This study is limited by small sample size, particularly in the analysis of incident disease. Definition of incident disease is dependent on clinical diagnosis within data systems, and likely an undercount and delayed time to event from disease onset.

Conclusions

This study demonstrates substantial burden of CKM diseases within Aboriginal communities of Central Australia. The majority of individuals had CKM syndrome risk factors. Without urgent action to address the underlying social determinants which drive and pattern behavioural and biological responses, disparities are likely to continue to widen. Within the health sector, this requires re-calibration of disease prevention and management strategies. Primary and secondary prevention must go beyond single-organ management, with systems to initiate holistic, interdisciplinary care coordination following first diagnosis.

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Author Contributions

K.F.B. undertook data curation, formal analysis and writing - original draft. A.D.H.B. was responsible for conceptualisation, funding acquisition, methodology, investigation, project administration, and writing – reviewing and editing. N.J.H. was responsible for data curation, formal analysis and writing – reviewing and editing. C.P. was responsible for formal analysis and writing – reviewing and editing. M.J.C. was responsible for writing – reviewing and editing.

Data Statement

Research data are not shared due to the sensitive nature of the research.

Declaration of Competing Interests

The authors declare no conflicts of interest.

Appendices

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.hlc.2025.08.016.

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