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CARDIOMETABOLIC RISK AND DISEASE IN INDIGENOUS AUSTRALIANS: THE HEART OF THE HEART STUDY

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ABSTRACT

Objectives:

This study assessed the burden and determinants of cardiovascular and metabolic risk in a community sample of high risk Indigenous Australians.

Background:

Indigenous Australians are over-represented in the most disadvantaged strata of Australian society. The role of psychosocial and socioeconomic factors in patterning cardiometabolic disease in this population is unclear.

Methods

The Heart of the Heart Study was a cross sectional study of 436 Aboriginal adults from remote, urban and peri-urban communities around Alice Springs (Northern Territory, Australia). Participants underwent detailed assessments of socio-demographic, psychosocial, cardiovascular and metabolic status.

Results:

Individuals with depression were twice as likely to have cardiovascular disease (OR 2.03; 1.07 – 3.88; $p<0.05$). Chronic kidney disease (39.7%, 37.2% and 18.2%) and diabetes (28.4%, 34.0% and 19.2%) was more common in peri-urban and remote compared to urban communities. Cardiovascular disease did not vary across locations ($p=0.069$), but coronary artery disease did ($p=0.035$ for trend). Unemployed individuals were more likely to have cardiovascular disease (OR 2.32; 1.33-4.06; $p<0.001$). Socioeconomic gradients in coronary artery disease, all cardiovascular disease and diabetes, as measured by income, operated differentially across locations (p for location/socioeconomic status interactions 0.002; 0.01 and 0.04 respectively).

Conclusion

Participants had high rates of pre-existing cardiovascular disease, diabetes and chronic kidney disease. Cardiovascular risk in these communities was associated with psychosocial factors and socioeconomic indicators. However, gradients operated differentially across location. These data provide a strong foundation

for better understanding key drivers of increased levels of cardiovascular and other common forms of non-communicable disease in Indigenous people.

KEYWORDS

Indigenous; cardiovascular disease; cardiometabolic; non-communicable disease; depression; socioeconomic factors.

INTRODUCTION

Despite representing only 2.5% of the population, Indigenous Australians are overrepresented in the most disadvantaged strata of society with life expectancy more than 10 years less than their non-Indigenous counterparts(1). Non communicable diseases (NCDs) are the principal contributors to this life expectancy gap, including cardiovascular disease (CVD), diabetes and chronic kidney diseases (CKD)(2). CVD alone is the primary cause of death among Indigenous Australians(2), accounting for 30% of all deaths and 33% of the life expectancy gap(3). Understanding NCDs in high risk groups can identify targets for overcoming disparity between populations defined by ethnicity or socioeconomic status, but also drivers of inequity within disadvantaged populations.

The determinants of CVD in Indigenous Australians are complex (4, 5). Traditional risk factors and adverse behaviours are important contributors to disparity (6, 7), but are unlikely to fully account for large differentials. The influence of contextual factors (features of the environments in which people live) and compositional factors (collective attributes of people residing within a particular place) (8) has received less attention, with limited research to define and understand the existence of heterogeneity in risk and burden of cardiovascular and related NCDs between and within Indigenous populations. What data exists suggests lower rates of CVD in remote dwelling Aboriginal people (9), yet the reasons for this remains unclear.

STUDY AIMS

The Heart of the Heart Study was designed to explore the burden and correlates of CVD, diabetes and CKD in community dwelling Indigenous adults living in the arid region of Central Australia. We postulated that a) there would be differences in the cardiometabolic profile of participants according to an individual's place of residence, their socioeconomic and psychosocial status, and that b) the relationship between cardiometabolic health and socioeconomic status would vary by location.

METHODS

Study setting and design

This cross-sectional study was conducted from May 2008 to November 2009 in a community sample of Aboriginal residents within Central Australia(10). Approximately 36,000 (11) people (40% Aboriginal) reside in this region of 546,046 km^2. We purposefully sampled a representative cohort of participants from

each of four remote communities (between 150 to 450 adult Aboriginal inhabitants situated between 10 to 400 km from Alice Springs), those living within the town of Alice Springs (approximately 2000 Aboriginal adults) and those living in small peri-urban communities on the fringes of Alice Springs ('Town Camps') (adult population of between 60 and 180 in each) (11). The study complies with the Declaration of Helsinki and was approved by the Central Australian Human Research Ethics Committee and the Monash University Standing Committee on Ethics in Research Involving Humans.

Participants

Participants were considered eligible if they were aged ≥ 18 years; self-reported Indigenous residents of Central Australia; and able to provide informed consent. In total 436 volunteers underwent comprehensive cardiovascular assessments. The proportion of the regional target population assessed were 5% in Alice Springs town (n=113), 17% of Town Camps adults (n=103) and 4% (n=220) of remote community residents.

Data Collection

Each participant was subject to structured questionnaire and clinical record review, and comprehensive clinical examination (including echocardiography- reported elsewhere (10)). Data included age; residence; socioeconomic status - income, education, employment; psychosocial status including depressive symptoms (using an adapted Patient Health Questionnaire-9 (PHQ9)(12); smoking status; past medical history (including prior documentation of CVD, diabetes, CKD, hypertension and elevated blood lipids) and current medications. The Rose Angina questionnaire was completed (13, 14), alongside measurement of blood pressure (BP), height, weight, abdominal and hip circumference (15); electrocardiography (ECG) [Universal ECG™ and Office Medic™ Software QRS Diagnostic, MN, USA] and echocardiography. Venous blood was taken for analyses of lipid, glycosylated haemoglobin (HbA1c), renal, thyroid and liver function, full blood count, and inflammatory markers (C-reactive protein). B-type natriuretic peptide (BNP) was measured utilising a point-of-care Triage® System (Alere™, MA, USA). Spot urine samples were collected for albumin:creatinine ratio (ACR). Reports describing an individual's risk profile and 5-year absolute CVD risk (16, 17) were explained to the participant by a research nurse.

Study definitions

Elevated blood pressure was defined on an individual basis depending on baseline risk and disease (18). Elevated blood lipid levels were defined according to target lipid levels within national guidelines (19).

Obesity was defined as BMI ≥ 30 kg/m^2 (20) . Elevated depressive symptomatology was indicated by a score of ≥ 10 on the PHQ-9(12). CAD was defined as a past medical history of acute myocardial infarction, unstable angina, angina or positive prior angiography, ECG evidence of Q-waves(21) (reviewed independently by two investigators (GL and SS) and adjudicated by CZ or recognition of *definitive* angina on the Rose Angina Questionnaire (Grade 1, all features of angina present)(22). All heart disease was defined as presence of rheumatic heart disease (RHD), non-rheumatic valvular disease, atrial fibrillation, CAD, heart failure or any other documented cardiac condition. CVD was defined as presence of heart disease (as defined above), peripheral vascular disease or cerebrovascular disease. All echocardiographic reports were reviewed to identify valve disease in accordance with contemporary guidelines(23). Diabetes was defined as a medical history of diabetes, treatment with oral hypoglycaemic agents or insulin or a HbA1c ≥ 6.5% (24). CKD was defined as estimated glomerular filtration rate (eGFR) <60mL/min/1.73m^2 and/or ACR > 2.5 mg/mmol for men and >3.5 mg/mmol for women (25) or a documented past history of CKD.

Data Analyses

Data were analysed using SPSS Statistics 19.0. Normally distributed continuous data are presented as the mean ± standard deviation and non-Gaussian distributed variables as the median plus interquartile range. Discrete variables were analysed via odds ratios (OR) with 95% confidence intervals (CI) or χ^2 analyses. Multiple logistic regression models were used to explore the contribution of psychosocial and socioeconomic factors to the presence of NCDs; initially on age and sex-adjusted basis and then a full entry model (age, sex, education, income, community, employment status and depressive symptoms). All disease rates were standardised for age and sex relative to the NT Aboriginal population as enumerated in the 2006 ABS Census(11). Variation across locations in the relationship of disease to SES indicators was tested using binary logistic regression. Initial models included age, sex, location and SES indicator (one of employment status, income group, or years of education). A second model including the interaction term of 'location' X 'SES indicator' was constructed to test for difference between locations in the relationship of disease to SES. Because of small number of cases in some strata, models were sometimes unstable (indicated by large standard errors for regression coefficients); in these instances outliers were examined and excluded if residual Z-scores were >2, and models re-run.

RESULTS

Study cohort

Table 1 summarises the socio-demographic, medical history and risk factors according to residence. There was variation in socio-demographic characteristics across location with more women participating within Town Camps and remote areas. Participants from Alice Springs were older, reported higher income, more years of education and were less likely to report being unemployed. Town Camps had the largest proportion of participants with a low income (63%) (<$400/fortnight), <10 years of education (61%) and who were unemployed (77%).

Cardiovascular risk according to location

More than one third of participants were smokers, and around half had been previously diagnosed with hypertension. The mean BMI of participants was in the obese range (30.0±6.8) and average HbA1c across all sites was above 6.5%. On an unadjusted basis, participants from Alice Springs had higher systolic BP, elevated total and LDL cholesterol, poorer kidney function (as evidenced by reduced eGFR and elevated ACR), and were more likely to report depressive symptoms.

Age and sex-based differences in cardiovascular risk

There was little difference between men and women with respect to most risk factors except smoking and obesity (Figure 1). Men were more likely to smoke ($p<0.001$), and obesity was more common in women ($p<0.001$). Among women there was higher risk across age strata for all risk factors ($p<0.001$ for linear trend) except for obesity ($p=0.562$). For men, smoking decreased with age ($p=0.005$ for linear trend) and diabetes and elevated BP increased ($p<0.001$). Over 70% of men and women had elevated LDL-C and elevated BP (from 35 years onwards) and almost 60% of people aged > 45 years had diabetes.

Psychosocial and socioeconomic correlates of CVD

Advancing age was the most consistent correlate of increased odds of CVD (adjusted OR 1.05 – 1.07 per year) (Table 2). Adjusting for age, sex, income, education and depressive symptoms, unemployed individuals were >2-fold more likely to have heart disease or any form of CVD, but not diabetes or CKD. Those with elevated depressive symptoms were 2 times more likely to have heart disease or CVD independent of all other risk factors. Individuals living in an urban setting were 67% less likely to have CKD compared to remote or Town Camp residents. The odds of having CVD were significantly lower among remote community residents compared to those in Town Camps.

Age and sex-standardised prevalence of selected non-communicable diseases

The prevalence of CAD (p=0.035), diabetes (p=0.023) and CKD (p=0.001) when standardised against the NT Aboriginal population, varied significantly across locations (Figure 2).

Socioeconomic status and non-communicable disease according to location

There was variation across locations in the association between cardiovascular risk and income. This difference was statistically significant for heart disease (p=0.002), all forms of CVD (p=0.01) and diabetes (p=0.04), but not for CKD (p=0.63; Table 3). For CAD, higher income was associated with lower odds for Alice Springs residents, associated with elevated risk in Town Camps, but had little or no effect in remote communities: the slope of this relationship in urban Alice Springs was different to that in Town Camps (p=0.001) and remote communities (p=0.009). Similar patterns were observed for CVD overall: higher income was associated with greater risk of CVD in Town Camps and this was significantly different to the association in remote communities (p=0.006) and Alice Springs (p=0.026). Likewise diabetes risk was lower for Alice Springs residents on higher incomes but this was not the case in Town Camps (p=0.031 versus the association in Alice Springs) or remote communities (p=0.013).

Associations of CVD risk to employment status were in the expected direction for Alice Springs residents (that is, lower risk among employed persons) but this association was generally absent in remote communities and variable in Town Camps and did not reach statistical significance for any of the conditions examined. There was no significant relationship of years of education to risk of any NCD.

DISCUSSION

The Heart of the Heart Study reports a unique assessment of cardiometabolic risk, geographic dispersion and correlates in Indigenous people. We found high levels of risk and pre-existing CVD, diabetes and CKD within both sexes, across all locations and within all age groups. Almost half of all participants had a documented history of hypercholesterolaemia or hypertension, one third had pre-existing diabetes, one fifth had CKD and a similar proportion documented CVD. When combined with objective clinical and/or biochemical measures, two thirds of the cohort (63.3%) had elevated BP (irrespective of concurrent treatment), and approximately 40% had diabetes, obesity and CKD. Almost one quarter of the cohort had evidence of CVD, much higher than nationally available self-reported prevalence rates (26).

These are the first data to our knowledge reporting a strong, independent relationship between psychological factors and CVD in Aboriginal communities (27). Indigenous Australians are a group at particularly high

risk of developing psychological illness given their experience of socioeconomic disadvantage, social marginalisation, community dysfunction, and racism (28, 29). Yet the role of these factors in driving disparate rates of CVD has yet to be elucidated. In this cohort, elevated depressive symptoms were associated with a two-fold increased risk of CVD.

Our a-priori hypothesis, that income, education and employment status would be associated with disease, but that the gradients would operate differentially according to location was supported, at least in part. We found that not only did socioeconomic status vary across locations, but it may well influence the risk of disease differentially across sites. A number of studies have previously described the burden of NCD and their common antecedents in Indigenous people in Australia,(7, 9, 30, 31), the majority within single communities, single geographical locations (urban or remote), focused on risk factor status or self-reported disease status alone. These approaches are problematic insofar as they do not allow detailed exploration of disparities across and within Indigenous populations defined by socioeconomic, geographical or environmental factors.

Previous work has also identified geospatial patterning of kidney disease in Australian Aboriginal communities (32), with remote dwelling Indigenous people up to 30 times more likely to develop end stage renal disease. Surveys have also reported high levels of inflammatory markers in Aboriginal people (33). Increased exposure to adverse environmental conditions, a high burden of infectious diseases and socioeconomic disadvantage may drive higher rates of renal disease in remote communities. In contrast, urbanised Aboriginal participants demonstrated elevated rates of hypercholesterolaemia, depressive symptomatology and higher rates of CVD.

While the association between income and NCDs varied significantly according to location, the prevalence of CVD, diabetes or CKD was not associated with income categories in remote dwelling individuals. However, in urbanised Aboriginal participants, those on higher incomes were less likely to have prevalent CVD, diabetes or CKD. In Town Camp residents the opposite pattern was observed. An inverse association between socio-economic status and health is well described (34, 35). Historically, CVD has not been experienced equally across populations defined by social class, geography or ethnicity. However, these broad generalities hide the existence of heterogeneity in socioeconomic gradients (36). Understanding the skewed distribution of socioeconomic resources within and across population groups is important, not only to

understand how disadvantage drives ill health, but because health policy must be framed by empirical data that helps to understand what interventions are likely to make a difference and amongst which sectors of the community.

Limitations

Any interpretation of these data requires appreciation of the enormous challenges posed by conducting research within the small, dispersed, remote populations in Central Australia. Nevertheless, caution should be exercised when considering whether or not these data are representative of the broader Indigenous population of Australia. Relatively small numbers precluded assessment of gender specific socioeconomic gradients in NCD prevalence. This study also undertook an incomplete audit of contextual factors, with additional data beyond homogenised representations of location absent, leaving the results still inferential in terms of contextual factors that may influence NCD risk. Finally, there can be no assessment of causality with cross sectional data.

Conclusions

This unique study undertook detailed objective assessment of cardiometabolic, psychosocial and socioeconomic factors in a volunteer cohort of Aboriginal adults. Participants had very high rates of CVD, diabetes and CKD and cardiometabolic risk despite their young age. Cardiovascular risk, in particular, was associated with psychosocial factors and socioeconomic indicators. However, associated gradients operated differentially across and importantly within geographic location. These data provides a strong framework for better understanding key drivers of increased levels of cardiovascular and other common forms of NCD in Indigenous people.

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Table 1: Socio-demographic, risk and clinical profile according to location (n = 436)

	ALL n = 436	Alice Springs (n = 103, 24%)	Town Camps (n = 113, 26%)	Remote (n = 220, 50%)	p value
Socio-demographic profile					
Female	64%	52%	68%	68%	.014
Age (years)	43.8 ± 14.2	48.0 ± 13.0	42.4 ± 15.3	42.5 ± 13.8	.003
Income (fortnight):					
$0 - $399	47%	19%	63%	52%	<0.001
$400 - $799	32%	36%	31%	31%	
Over $800	21%	45%	6%	18%	
<10 years education	44%	29%	61%	43%	<0.001
Unemployed	58%	34%	77%	59%	<0.001
Past history					
Hypercholesterolemia	43%	52%	34%	44%	.020
Hypertension	48%	52%	43%	49%	.329
Diabetes	34%	34%	32%	36%	.806
Renal disease	18%	11%	15%	23%	.015
Any heart disease:	17%	22%	20%	14%	.153
Rheumatic	7%	8%	11%	6%	.227
Valve	4%	3%	3%	5%	.615
AF	3%	3%	2%	3%	.835
CAD	8%	14%	9%	5%	.028
Chronic heart failure	2%	4%	1%	1%	.198
Cerebrovascular disease	3%	6%	2%	2%	.147
Clinical Profile					
Current smoker	38%	42%	43%	34%	.223
Heart rate (beats/min)	82 ± 12	78 ± 12	85 ± 13	83 ± 11	<0.001
Systolic BP (mmHg)	130 ± 20	133 ± 18	132 ± 21	127 ± 19	.018
Diastolic BP (mmHg)	82 ± 13	83 ± 12	83 ± 14	81 ± 13	.225
BMI (kg/m^2)	30.0 ± 6.8	29.5 ± 6.8	29.4 ± 7.2	30.4 ± 6.7	.346
Total cholesterol (mmol/L)	4.7 ± 1.2	4.8 ± 1.1	4.8 ± 1.3	4.5 ± 1.1	.032
LDL cholesterol (mmol/L)	2.6 ± 1.0	2.8 ± 1.0	2.6 ± 1.1	2.5 ± 0.9	.095
HDL cholesterol (mmol/L)	1.0 ± 0.3	1.1 ± 0.3	1.1 ± 0.3	0.9 ± 0.3	<0.001
eGFR ($ml/min/1.7m^2$)	101 ± 30	94 ± 24	95 ± 32	108 ± 31	<0.001
Albumin/creatinine ratio	1.9 [0.7 - 8.7]	1.0 [0.5 – 5.0]	3.0 [0.8 – 24.0]	2.2 [0.8 – 8.6]	<0.001
HbA1c (%)	6.9 ± 1.9	6.6 ± 1.8	6.9 ± 1.8	7.1 ± 2.0	.154
CRP (mg/L)	5 [2 – 10]	4 [2 – 8]	6 [2 – 11]	6 [3 – 11]	<0.001
BNP (pg/mL)	7.2 [5.0 – 16.1]	8.3 [5.0 – 19.3]	7.9 [5.0 – 19.9]	6.1 [5.0 – 13.6]	.041
PHQ9 Score	6 ± 4	7 ± 4	7 ± 5	5 ± 4	<0.001
High risk alcohol drinker (%)	22%	20%	36%	15%	<0.001
Absolute CVD risk score (%)	7.6 ± 7.8	9.2 ± 8.2	7.5 ± 8.3	7.0 ± 7.3	.058
LVEF (%)	59 ± 7	59 ± 7	59 ± 8	58 ± 6	.869

AF (atrial fibrillation); CAD (coronary artery disease); CHF (chronic heart failure); BP (blood pressure); BMI (body mass index); eGFR (estimated glomerular filtration rate); CRP (c-reactive peptide); BNP (Brain natriuretic peptide); PHQ9 (patient health questionnaire 9); LVEF (left ventricular ejection fraction).

Table 2: Psychosocial risk factors associated with diabetes, renal disease, heart disease and CVD (n=370, 85%)

	Diabetes	Renal Disease	All Heart Disease	All CVD
Age (years) Cases *versus* others	50 ± 12 *vs.* 39 ± 14 OR 1.07 (1.05 – 1.08)***	48 ± 13 *vs.* 41 ± 14 OR 1.05 (1.03 – 1.06)***	51 ± 14 *vs.* 42 ± 13 OR 1.05 (1.03 – 1.07)***	52 ± 14 *vs.* 41 ± 13 OR 1.05 (1.04 – 1.07)***
Male *versus* female	38% *vs.* 43% OR 0.85 (0.55 – 1.33)	42% *vs.* 39% OR 1.29 (0.84 – 1.98)	20% *vs.* 23% OR 0.88 (0.52 – 1.49)	21% *vs.* 25% OR 0.79 (0.48 – 1.30)
Education Status: <10 years *vs.* >10 years	41% *vs.* 36% OR 0.87 (0.53 – 1.42)	42% *vs.* 36% OR 0.87 (0.54 – 1.40)	26% *vs.* 18% OR 1.26 (0.72 – 2.23)	28% *vs.* 20% OR 1.24 (0.71 – 2.16)
Community: *Town Camps* *Alice Springs* *Remote Community*	 39% OR *1.00 (ref)* * 36% OR 0.63 (0.34 – 1.17) 45% OR 1.36 (0.82 – 2.26)	 46% OR *1.00 (ref)* 29% OR 0.33 (0.18 – 0.61)** 42% OR 0.84 (0.52 – 1.37)	 29% *1.00 (ref)* 23% OR 0.79 (0.39 – 1.59) 18% OR 0.60 (0.33 – 1.07)	 30% *OR 1.00 (ref)* 28% OR 0.72 (0.38 – 1.36) 19% OR 0.51 (0.29 – 0.89)*
Income: *$AU 0 to 399* *$AU 400 to 799* *$AU ≥ 800*	 43% *OR 1.00 (ref)* 42% OR 0.88 (0.50 – 1.56) 32% OR 0.96 (0.44 – 2.11)	 44% *OR 1.00 (ref)* 41% OR 0.96 (0.56 – 1.65) 31% OR 1.03 (0.48 – 2.23)	 26% *OR 1.00 (ref)* 21% OR 0.95 (0.50 – 1.79) 14% OR 1.07 (0.37 – 3.05)	 27% *OR 1.00 (ref)* 23% OR 0.99 (0.53 – 1.87) 17% OR 1.14 (0.42 – 3.15)
Employment Status: Unemployed *vs.* employed	45% *vs.* 34% OR 1.22 (0.77 – 1.93)	47% *vs.* 32% OR 1.40 (0.89 – 2.19)	30% *vs.* 13% OR 2.31 (1.30 – 4.08)**	32% *vs.* 15% OR 2.32 (1.33 – 4.06)**
Mental health: Depressive symptoms *vs.* none	46% *vs.* 39% OR 1.49 (0.87 – 2.58)	40% *vs.* 40% OR 1.06 (0.62 – 1.82)	30% *vs.* 21% OR 1.94 (1.01 – 3.75)*	33% *vs.* 22% OR 2.03 (1.07 – 3.88)*

Adjusted significance (entry model with all variables) - *p<0.05, **p<0.01, ***p<0.001. Number of cases available for analysis: age and sex (all), education (n=386), income (n=411), employment (n=418) and mental health (n=425).

Table 3: Age and sex-standardised prevalence of selected chronic conditions by location and socioeconomic status.

		Urban Alice Springs (n=103)	Town Camps (n=113)	Remote (n=220)	P* location X SES
CAD	Income <$400	20.5	7.8	2.9	**0.002**
	Income >=$400	5.0	19.2	6.4	
	Unemployed	25.3	16.8	3.5	0.150
	Employed	3.3	0	6.1	
	Education <10yrs	3.5	13.5	6.3	0.772
	Education >=10yrs	7.3	12.2	4.0	
CVD	Income <$400	29.0	21.8	18.9	**0.01**
	Income >=$400	13.0	26.7	10.3	
	Unemployed	30.1	31.8	17.7	0.107
	Employed	12.3	2.8	12.3	
	Education <10yrs	11.7	29.5	18.8	0.655
	Education >=10yrs	13.0	20.9	12.0	
Diabetes	Income <$400	36.0	28.7	31.4	**0.040**
	Income >=$400	13.4	29.3	38.3	
	Unemployed	33.9	28.0	33.2	0.191
	Employed	11.3	19.6	35.7	
	Education <10yrs	11.5	28.5	33.8	0.258
	Education >=10yrs	18.3	25.0	31.2	
CKD	Income <$400	26.2	41.7	38.5	0.630
	Income >=$400	15.8	36.1	34.9	
	Unemployed	31.0	44.4	41.2	0.203
	Employed	15.3	17.0	36.2	
	Education <10yrs	15.0	36.0	37.2	0.512
	Education >=10yrs	15.4	44.2	33.7	

* p-value from logistic regression models including age, sex, location SES category, and also including interaction term for location X SES category.