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ORIGINAL RESEARCH

Rural-Urban Differences in Outcomes of Acute Cardiac Admissions in a Large Health Service

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ABSTRACT

BACKGROUND Cardiovascular disease (CVD) is a leading cause of morbidity and mortality and residing in a rural and remote region is associated with an increased risk. The impact of rurality on CVD outcomes needs to be fully elucidated.

OBJECTIVES The purpose of this study was to assess the difference in mortality, readmission within 30 days, total readmissions, survival, and total emergency department (ED) presentations following an index CVD admission among patients from rural or remote areas as compared to metropolitan areas.

METHODS This retrospective observational study included all index hospitalizations with heart failure (HF), atrial fibrillation (AF), or acute coronary syndrome (ACS) within the Hunter New England region of Australia, between January 1, 2008, and December 31, 2021.

RESULTS There were 27,995 ACS admissions, 15,586 HF admissions, and 16,935 AF admissions. Patients from a rural or remote area presenting with CVD presentations had increased 30-day readmission (OR: 1.19; $P < 0.001$), an increased number of readmissions (incident rate ratio: 1.19; $P < 0.001$), and more ED presentations (incident rate ratio: 1.39; $P < 0.001$) as compared to patients from metropolitan areas. This was consistent across patients presenting with ACS, HF, and AF. There was no difference in mortality (HR: 1.01; $P = 0.515$). However, in the ACS subgroup, there was increased mortality in the rural and remote population (HR: 1.05; $P = 0.015$).

CONCLUSIONS This study highlights the increased incidence of ED presentations and hospital readmissions, for those living in rural Australia, illustrating the disparity in health care provided, and the ongoing need for interventions that address poorer access to specialized health care in the early discharge phase of hospitalization. (JACC Adv. 2024;3:101328) Crown Copyright © 2024 Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

ACS = acute coronary syndrome

AF = atrial fibrillation

CVD = cardiovascular disease

ED = emergency department

HF = heart failure

HNELHD = Hunter New England Local Health District

ICD-10 = International Classification of Diseases-10th revision

IRR = incident rate ratio

Cardiovascular disease (CVD) continues to be one of the leading causes of morbidity and mortality in Australia.[1] The most common cardiovascular presentations to the emergency department (ED) include heart failure (HF), acute coronary syndrome (ACS), and atrial fibrillation (AF), with 83%, 78%, and 68% of patients, respectively, admitted to the hospital for ongoing care.[1] The rates of presentation with CVD as the principal diagnosis is 2.3 times higher among the First Nations people of Australia as well as 1.6 times higher among people from remote or very remote areas compared to major cities.[1]

Overall coronary heart disease deaths have declined significantly since 1980, however the risk in remote and very remote populations is 1.6 times greater than in metropolitan areas.[1] This disparity is consistent for HF with a mortality of 66 deaths per 100,000 population in the metropolitan population versus 103 deaths per 100,000 population in the rural population, as well as for AF population with 40 deaths per 100,000 population living in major cities versus 53 deaths per 100,000 population for those from a rural or remote area.[1] In addition, hospitalization is higher among people living in rural and remote areas as compared to major cities, for HF, coronary heart disease, and AF.[1] However, there are limited data regarding readmission and mortality in rural patients.[2]

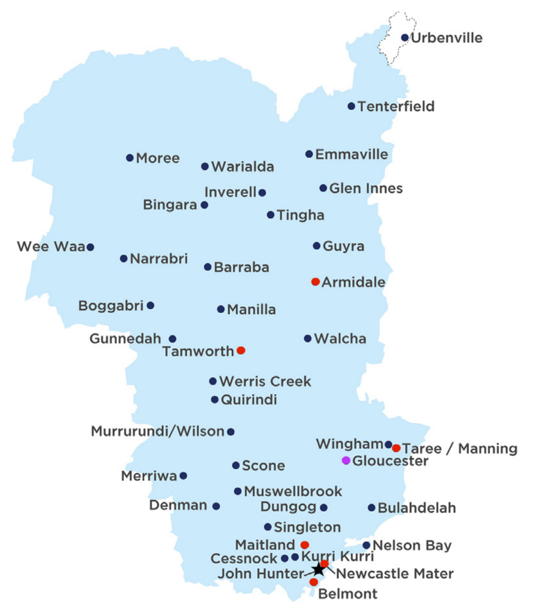
It is estimated that about 7 million, or 28%, of the population of Australia live in rural or remote areas.[3] The United Nations estimated in 2018 that 3.4 billion people globally reside in a rural area, with the rural population to peak in the next few years.[4] Studies have shown the negative impact of rurality on CVD admissions in low socioeconomic countries,[5-7] as well as in developed countries like the United States.[8-14] There have been limited studies exploring the differential impact of rurality on HF, ACS, and AF, and associated readmission and ED presentation in Australia.

This study aims to assess the mortality, 30-day readmissions, total readmission count, 12-month survival, and total ED presentation count (patient level) following an index CVD admission, between rural and metropolitan setting over a 14-year period.

METHODS

STUDY SETTING AND PARTICIPANTS. We identified all index hospitalizations with AF, ACS, and HF in the Hunter New England (HNE) region from January 1, 2008 until December 31, 2021. The HNE region of New South Wales, Australia, covers an area of over 130,000 km^2 and serves a population of 962,000, of whom approximately 45% live in metropolitan areas and 55% in regional or rural settings. Approximately 7% of the population are Aboriginal or Torres Strait Islanders. The Hunter New England Local Health District (HNELHD) comprises 37 hospitals, including general practitioner run hospitals (n = 27), general physician on site/Fellow Australasian College of Emergency Medicine hospitals (n = 7), nurse-only hospitals (n = 2), and a tertiary referral center (n = 1) (Figure 1).

FIGURE 1 The Hunter New England Area Health District



Blue circles are GP (primary care physician) operated emergency departments/inpatient units; red circles are general physician (Internalist)/cardiologist/fellow of australiasian college of emergency medicine operated emergency departments/inpatient units; purple circle nurse operated emergency departments/inpatient units; star is tertiary referral hospital for the area.

Demographic and administrative data, as well as past medical history and comorbidities were prospectively collected from electronic medical records on all hospitalized patients in HNELHD hospitals. Hospitalizations with an International Classification of Diseases-10th revision (ICD-10) code for HF, AF, ACS, as a principal diagnosis or one of the first three secondary diagnoses on discharge, were extracted. Care outcome data were sourced from the HNELHD Institutional Cardiac and Stroke Outcomes Unit database, which prospectively registers all public hospital admissions using consistent methodology [15] and included hospital readmissions, ED presentations, in-patient death, and all-cause mortality, obtained from the state Births Deaths and Marriages Register. Rurality was defined using the Accessibility/Remoteness Index of Australia; as major city (metropolitan) compared to inner regional, outer regional, and remote (rural). We identified the ICD10 codes for hypertension, diabetes mellitus, renal failure, and chronic lower respiratory disease, on discharge documentation of the index hospital admission. The ethics approval for the study was granted by HNE Human Research Ethics Committee (AU202204-11).

INCLUSION AND EXCLUSION CRITERIA. Of the 63,385 patient records identified, CVD category was obtained by first identifying all patients where a CVD event was listed under the principal diagnosis field. ICD codes were utilized to categorize these into HF, AF, and ACS, with first CVD diagnosis encountered from primary or secondary diagnosis determining the CVD category. Patients were enrolled after initial CVD admission, which determined their enrollment CVD category, subsequent readmissions were only included within total readmission count. Patients who died in hospital were excluded from the readmission and ED presentation analyses. All patients were included in the survival analyses and admission trend over time analysis. Patients who were aged<18 years were excluded from the analysis.

OUTCOME MEASURES. The outcome measures were as follows: readmission within 30 days, total readmission count (patient level) following the index admission, survival (all-cause mortality prior to extraction end date), and total ED presentation count (patient level) following the index admission. In order to estimate the monthly rate of admissions per 10,000 residents, an estimate for the number of residents in the HNE-LHD area was needed. Yearly data were obtained from https://www.healthstats.nsw.gov.au, for residents aged 15 years and older. The monthly rate per 10,000 was then calculated as the number of admissions per calendar month, divided by the population count for the same year. The period of analysis encompassed the COVID-19 pandemic, as COVID-19 period (defined as between March 23, 2023 and October 15, 2021) was adjusted for in the models, to minimize the effect of the COVID-19 pandemic on outcomes and on different CVD subtypes.

STATISTICAL METHODS. Median and interquartile range were used to summarize continuous variables and numbers and percentages for binary variables. The characteristics of patients were also compared across the CVD categories (AF, HF, ACS), using chi-squared analysis.

Logistic regression (readmission within 30 days), Cox proportional hazard survival models (all-cause mortality), and negative binomial regressions (total readmission count and ED visit count) were used to examine associations of the outcomes of interest. Crude models were performed, with rurality as the only predictor. Models were then adjusted for CVD subtype, COVID period, the interaction between rurality and covid period, rurality and CVD subtype, and CVD subtype and covid period, as well as the demographic characteristics (sex, age, Indigenous status), and comorbidities (atherosclerosis, hypertension, lipidemia, stroke, transient ischemic attack, renal, diabetes, respiratory, pulmonary embolism deep vein thrombosis, fall, anemia, obesity, smoking, alcohol).

For logistic regression models, cooks D was used to identify influential data points—multiple points were identified, however their exclusion did not significantly change the results—likely because of the large sample size. There was also no clear reason to exclude them as outliers, and so they were kept in the model.

Leverage statistics were also calculated, and all were deemed acceptable (<0.2). Standard errors for covariates were checked for potential model overfit. Age was categorized to meet the linearity assumptions. Finally, residual plots were checked for evidence of lack of homogeneity and were found to be satisfactory. Deviance and Pearson GoF statistics were also assessed and found to be nonsignificant.

For the Cox proportional hazard models—plots were utilized to assess the proportionality assumption, which was deemed to be satisfactory for all models. Deviance residuals were plotted to check for outliers, as well as Schoenfeld residuals, and found to be satisfactory (in some cases outliers were identified—but their exclusion from the model did not change the results—likely due to the very large sample size, and so were included in the final model).

For the count outcomes, Poisson regression was initially trialled but found to be over-dispersed, so a negative binomial was utilized instead. Residual plots were examined and found to be satisfactory. Outliers and influential observations were checked for, however due to the large sample size their exclusion did not change the results significantly or meaningfully, and so were left in the model.

For segmented regression, the normal distribution was assumed—residuals plots were used to check for normality and homogeneity and found to be satisfactory, no outliers were identified.

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TABLE 1 Baseline Clinical Characteristics by CVD

	Heart Failure Patients (n = 15,586)	Atrial Fibrillation (n = 16,935)	Acute Coronary Syndrome (n = 27,995)	*P* Value
Demographics				
Age				
<65 y	2,141 (14%)	4,464 (26%)	11,546 (41%)	
65-75 y	3,393 (22%)	4,958 (29%)	7,791 (28%)	<0.001
>75 y	10,091 (65%)	7,567 (45%)	8,782 (31%)	
Male	7,845 (50%)	8,865 (52%)	17,591 (63%)	<0.001
Marital status				
Never married	1,525 (9.8%)	1,553 (9.2%)	3,282 (12%)	
Widowed	6,070 (39%)	4,858 (29%)	5,580 (20%)	<0.001
Divorced	1,125 (7.2%)	1,152 (6.8%)	2,163 (7.7%)	
Separated	16 (2.0%)	385 (2.3%)	876 (3.1%)	
Married (including defacto)	6,578 (42%)	9,016 (53%)	16,162 (58%)	
ARIA classification				
Major city	7,710 (49%)	7,033 (42%)	12,936 (46%)	<0.001
Inner or outer regional, remote, and very remote	7,876 (51%)	9,902 (58%)	15,059 (54%)	
Aboriginal or Torres Strait Islander	559 (3.6%)	544 (3.2%)	1,539 (5.5%)	<0.001
Comorbidities				
Prior hypertension	6,811 (44%)	5,724 (34%)	15,565 (55%)	<0.001
Prior diabetes	4,074 (26%)	2,337 (14%)	5,911 (21%)	<0.001
Prior chronic renal disease	3,985 (26%)	1,453 (8.6%)	2,961 (11%)	<0.001
Chronic lower respiratory disease	4,007 (26%)	1763 (10%)	2,406 (8.6%)	<0.001
Outcome measures				
Total number of emergency presentations postdischarge				
Mean ± SD	2.01 ± 4.97	2.96 ± 6.21	2.99 ± 6.30	
Median (Q1, Q3)	1.00 (0.00, 2.00)	1.00 (0.00, 4.00)	1.00 (0.00, 4.00)	<0.001
Readmission within 30 d	2,959 (21%)	2,359 (14%)	3,787 (14%)	<0.001
30-d mortality	1,695 (11%)	478 (2.8%)	1704 (6.1%)	<0.001
1-y mortality	4,832 (31%)	1895 (11%)	3,237 (12%)	<0.001

Values are n (%) unless otherwise indicated.
ARIA = Accessibility/Remoteness Index of Australia; CVD = cardiovascular disease.

All statistical analyses were programmed using SAS version 9.4 (SAS Institute). Statistical significance was defined as a 2-tailed *P* value <0.05, there was no adjustment for multiple testing and estimates should be interpreted with caution.

RESULTS

ADMISSIONS. Between January 1, 2008, and December 31, 2021, there were 27,995 ACS admissions, 15,586 HF admissions, and 16,935 AF admissions. Detailed patient characteristics are presented in Tables 1 and 2. The age at presentation varied between each group, with 65% of patients presenting with HF aged over 75 years of age, while only 41% of patients AF and 31% of patients presenting with ACS were over 75 years of age. There was an even distribution of admissions between males and females presenting with HF and AF, however males were more likely to present with ACS (63% vs 37%).

READMISSIONS AND ED PRESENTATIONS. The number of readmission at 30 days was higher among patients presenting with HF (21%) as compared with ACS (14%) or AF (14%, $P < 0.001$) (Table 1). Patients from a rural or remote area presenting with a CVD presentation were more likely to have a readmission at 30 days (OR: 1.19; 95% CI: 1.14-1.24; $P < 0.001$; Central Illustration), as well as an increased rate of readmissions (incident rate ratio [IRR]: 1.19; 95% CI: 1.16-1.22; $P < 0.001$) and increased rate of ED presentations (IRR: 1.39; 95% CI: 1.35-1.43; $P < 0.001$) as compared to patients from metropolitan areas when adjusted for demographics and comorbidities (Table 3).

30-DAY READMISSION. Patients presenting with ACS and AF who were from a rural or remote area had a significantly increased risk of 30-day readmission as compared with patients from metropolitan areas (OR: 1.30; 95% CI: 1.21-1.40; $P < 0.001$ and OR: 1.14; 95% CI:

TABLE 2 Baseline Clinical Characteristics by CVD and Residence

	Heart Failure Patients (N = 15,586)		Atrial Fibrillation (N = 16,935)		Acute Coronary Syndrome (N = 27,995)	
	Metropolitan (n = 7,710)	Rural or Remote (n = 7,876)	Metropolitan (n = 7,033)	Rural or Remote (n = 9,902)	Metropolitan (n = 12,936)	Rural or Remote (n = 15,059)
Demographics						
Age						
<65 y	1,087 (14%)	1,045 (13%)	1817 (26%)	2,630 (27%)	5,385 (42%)	6,089 (40%)
65-75 y	1,599 (21%)	1,599 (21%)	1933 (27%)	3,006 (30%)	3,460 (27%)	4,296 (29%)
>75 y	5,024 (65%)	5,046 (64%)	3,283 (47%)	4,266 (43%)	4,091 (32%)	4,674 (31%)
Male	3,822 (50%)	4,001 (51%)	3,565 (51%)	5,271 (53%)	8,007 (62%)	9,491 (63%)
Marital status						
Never married	787 (10%)	732 (9.3%)	661 (9.4%)	882 (8.9%)	1,562 (12%)	1,698 (11%)
Widowed	3,065 (40%)	2,992 (38%)	2,188 (31%)	2,653 (27%)	2,666 (21%)	2,903 (19%)
Divorced	611 (7.9%)	512 (6.5%)	543 (7.7%)	606 (6.1%)	1,050 (8.1%)	1,101 (7.3%)
Separated	139 (1.8%)	177 (2.2%)	150 (2.1%)	233 (2.4%)	392 (3%)	478 (3.2%)
Married including defacto)	3,103 (40%)	3,457 (44%)	3,488 (50%)	5,506 (56%)	7,248 (56%)	8,842 (59%)
Aboriginal or Torres Strait Islander	198 (2.6%)	360 (4.6%)	159 (2.3%)	382 (3.9%)	480 (3.7%)	1,056 (7.0%)
Prior hypertension	3,583 (46%)	3,217 (41%)	2,429 (35%)	3,287 (33%)	7,118 (55%)	8,380 (56%)
Prior diabetes	2,131 (28%)	1934 (25%)	1,028 (15%)	1,302 (13%)	2,765 (21%)	3,121 (21%)
Prior chronic renal disease	2,214 (29%)	1766 (22%)	732 (10%)	721 (7.3%)	1,476 (11%)	1,471 (9.8%)
Chronic lower respiratory disease	1933 (25%)	2067 (26%)	662 (9.4%)	1,096 (11%)	978 (7.6%)	1,423 (9.4%)
Outcome measures						
Total number of emergency presentations postdischarge						
Mean ± SD	1.6 ± 4.38	2.4 ± 5.46	2.37 ± 4.5	3.36 ± 6.91	2.62 ± 6.02	3.31 ± 6.51
Readmission within 30 d	1,442 (20%)	1,512 (21%)	925 (13%)	1,426 (15%)	1,545 (13%)	2,228 (16%)
30-d mortality	776 (10%)	916 (12%)	204 (2.9%)	273 (2.8%)	744 (5.8%)	957 (6.4%)
1-y mortality	2,386 (31%)	2,441 (31%)	811 (12%)	1,083 (11%)	1,423 (11%)	1,809 (12%)

Values are n (%) unless otherwise indicated.
Abbreviation as in Table 1.

1.04-1.25; $P = 0.005$, respectively) (Table 4). This increased adjusted risk was also observed among patients from regional or remote areas who presented with HF, but the magnitude of this increased risk was lower (8%) and missed statistical significance (OR: 1.08; 95% CI: 1.00-1.17; $P = 0.064$) when adjusted for demographics and comorbidities.

READMISSION COUNT. There was a 5% greater rate of readmission among patients with HF who were from a regional or remote area (IRR: 1.05; 95% CI: 1.01-1.10; $P = 0.041$) on a univariable regression analysis and this remained when adjusting for demographics and comorbidities (IRR: 1.08; 95% CI: 1.03-1.13; $P = 0.003$). There was also a 13% higher rate of readmission among patients with AF from regional or remote areas than those from major cities on univariable regression analysis (IRR: 1.13; 95% CI: 1.08, 1.19; $P < 0.001$), this increased to 20% higher rate of readmission when adjusted for demographics and comorbidities (IRR: 1.20; 95% CI: 1.15-1.26; $P < 0.001$). Patients presenting with ACS from a regional or remote area had a 18% higher rate of readmission than those in major cities on univariable regression analysis (IRR: 1.18; 95% CI: 1.14, 1.23; $P < 0.001$), with a 23% increased readmission rate when adjusted for demographics and comorbidities (IRR: 1.23; 95% CI: 1.19-1.28; $P < 0.001$) (Table 4).

ED PRESENTATIONS. There was a significant effect for ED presentations, with patients in rural areas increased rate of presentation to the ED with HF at a 52% higher rate than those in major cities (IRR: 1.52; 95% CI: 1.42-1.62; crude model), this effect remained when accounting for comorbidities and demographics (IRR: 1.53; 95% CI: 1.45-1.63; $P < 0.001$). There was a similar unadjusted and adjusted (demographics/comorbidities) result for both AF and ACS subgroups with a 40% and 33% higher rate than those in major cities, respectively (IRR: 1.40; 95% CI: 1.33-1.47; $P < 0.001$ and IRR: 1.33; 95% CI: 1.27-1.39; $P < 0.001$, respectively) (Table 4).

Other factors that influenced 30-day HF readmission included chronic disease such as atherosclerosis, renal disease, respiratory disease, and anemia, with a 43%, 45%, 12%, and 37% increased risk, respectively (Table 5). This association with 30-day readmission was consistent across AF and ACS with

CENTRAL ILLUSTRATION Rural-Urban Differences in Outcomes of Acute Cardiac Admissions in a Large Health Service

All Index Hospitalizations With Acute Cardiac Syndrome (ACS), Atrial Fibrillation (AF), or Heart Failure (HF) Within the Hunter New England Region of Australia, Between January 1, 2008 and December 31, 2021 (n=60,516)

	ACS n=27,995	AF n=16,935	HF n=15,586
Major city	12,936 (46%)	7,033 (42%)	7,710 (49%)
Male	17,591 (63%)	8,865 (52%)	7,845 (50%)
30-day readmission	2,959 (21%)	2,359 (14%)	3,787 (14%)
30-day mortality	1,695 (11%)	478 (2.8%)	1,704 (6.1%)
1-year mortality	4,832 (31%)	1,895 (11%)	3,237 (12%)

Rural or Remote Patients With Cardiovascular Disease

↑ 30-day readmission (OR: 1.19; 95% CI: 1.14-1.24; P < 0.001)
Number of readmissions (IRR: 1.19; 95% CI: 1.16-1.22; P < 0.001)
Emergency department presentations (IRR: 1.39; 95% CI: 1.35-1.43; P < 0.001)

↔ No difference in mortality (HR: 1.01; 95% CI: 0.97-1.05; P < 0.515)

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The cardiovascular outcomes of patients residing within a rural or remote region, is driven largely by increased 30-day readmissions, number of readmissions, and number of emergency department presentations, without a difference in mortality. IRR = incident rate ratio.

additional demographic risk factors of age and indigenous status also influencing readmission (Table 5).

MORTALITY. The 30-day and 1-year mortality was higher among all patients presenting with HF as compared with ACS or AF (Table 1). Across all presentations, and after adjustment for demographic differences and comorbidities, patients from rural or remote areas had similar all-cause mortality (HR: 1.01; 95% CI: 0.97, 1.05; $P = 0.515$) (Table 3).

TABLE 3 The Effect of Rurality of Cardiovascular Disease Outcomes

	Rurality	Unadjusted Model	(95% CI)	P Value	Adjusted Model[b]	(95% CI)	P Value
CVD survival[a] (HR)	Rural	0.96	(0.93-1.00)	0.063	1.07	(1.03-1.11)	0.001
	Major city	Ref	-	-	Ref	-	-
CVD survival (HR)	Rural	0.94	(0.92-0.96)	<0.001	1.01	(0.98-1.03)	0.601
	Major city	Ref	-	-	Ref	-	-
CVD 30-d readmission (OR)	Rural	1.14	(1.09-1.19)	<0.001	1.19	(1.14-1.24)	<0.001
	Major city	Ref	-	-	Ref	-	-
CVD readmission count (IRR)	Rural	1.09	(1.06-1.12)	<0.001	1.19	(1.16-1.22)	<0.001
	Major city	Ref	-	-	Ref	-	-
CVD ED visit count (IRR)	Rural	1.41	(1.37-1.45)	<0.001	1.39	(1.355-1.43)	<0.001
	Major city	Ref	-	-	Ref	-	-

[a]Truncated at 12 months. [b]Adjusted for covid period, CVD group, age group, sex, Aboriginal status, marital status, atherosclerosis, hypertension, lipidemia, stroke, TIA < renal, diabetes, respiratory, PE DVT, fall, anemia, obesity, smoking, alcohol.

ED = emergency department; IRR = incident rate ratio; Ref = reference category; other abbreviation as in Table 1.

TABLE 4 The Effect of Rurality of Cardiovascular Disease Outcomes by Heart Failure, Atrial Fibrillation, and Acute Coronary Syndrome

	Subgroup	Rurality	Unadjusted Model	(95% CI)	*P* Value	Adjusted Model[b]	(95% CI)	*P* Value
CVD survival[a] (HR)	HF	Rural	1.01	(0.96-1.07)	0.666	1.05	(0.99-1.11)	0.120
	AF	Rural	0.95	(0.86-1.04)	0.233	1.02	(0.93-1.11)	0.722
	ACS	Rural	1.10	(1.02-1.18)	0.008	1.12	(1.05-1.21)	0.001
	Ref	Major city	-	-	-	-	-	-
CVD survival (HR)	HF	Rural	0.97	(0.94-1.01)	0.176	0.99	(0.96-1.03)	0.699
	AF	Rural	0.91	(0.86-0.95)	<0.001	0.96	(0.91-1.00)	0.064
	ACS	Rural	1.02	(0.98-1.07)	0.236	1.05	(1.01-1.09)	0.015
	Ref	Major city	-	-	-	-	-	-
CVD 30-d readmission (OR)	HF	Rural	1.05	(0.97-1.14)	0.249	1.08	(1.00-1.17)	0.064
	AF	Rural	1.11	(1.01-1.21)	0.022	1.14	(1.04-1.25)	0.005
	ACS	Rural	1.29	(1.20-1.38)	<0.001	1.30	(1.21-1.40)	<0.001
	Ref	Major cty	-	-	-	-	-	-
CVD readmission count (IRR)	HF	Rural	1.05	(1.01-1.10)	0.041	1.08	(1.03-1.13)	0.003
	AF	Rural	1.13	(1.08-1.19)	<0.001	1.20	(1.15-1.26)	<0.001
	ACS	Rural	1.18	(1.14-1.23)	<0.001	1.23	(1.19-1.28.)	<0.001
	Ref	Major city	-	-	-	-	-	-
CVD ED visit count (IRR)	HF	Rural	1.52	(1.42-1.62)	<0.001	1.53	(1.45-1.63)	<0.001
	AF	Rural	1.42	(1.35-1.50)	<0.001	1.40	(1.33-1.47)	<0.001
	ACS	Rural	1.36	(1.30-1.42)	<0.001	1.33	(1.27-1.39)	<0.001
	Ref	Major city	-	-	-	-	-	-

[a]Truncated at 12 months. [b]Adjusted for COVID period, CVD group, age group, sex, Aboriginal status, marital status, atherosclerosis, hypertension, lipidemia, stroke, TIA < renal, diabetes, respiratory, PE DVT, fall, anemia, obesity, smoking, alcohol.

ACS = acute coronary syndrome; AF = atrial fibrillation; HF = heart failure; other abbreviations as in Tables 1 and 3.

There was no association between rurality and all-cause mortality in the crude model for the ACS subgroup, but there was a higher mortality in rural and remote patients in the model adjusted for demographics and comorbidities (HR: 1.05; 95% CI: 1.01-1.09; $P = 0.015$; **Table 6**). There was a association between rurality and all-cause mortality for AF (HR: 0.91; 95% CI: 0.86-0.95), however on adjustment this became nonsignificant. There was no association between rurality and all-cause mortality in HF on the crude model or adjusted model (**Table 4**).

The results for the survival analysis, with follow-up censored at 12 months, illustrate that there was no significant effect of rurality on survival for the HF and AF subgroups, but there was a significant crude effect for rurality in the ACS subgroup (HR: 1.10; 95% CI: 1.02-1.18; $P = 0.008$). This effect remained in the ACS subgroup when adjusted for demographics and comorbidities (HR: 1.12; 95% CI: 1.05-1.21; $P = 0.001$) (**Table 4**).

DISCUSSION

This study illustrates the disparity in cardiac outcomes experienced by people living in rural and remote areas relative to those in urban areas. Patients living in rural/remote areas, admitted to hospital with an acute CVD presentation, experience higher 30-day readmission rates, total number of readmissions, and ED presentations, with no difference in all-cause mortality when accounting for demographics and comorbidities.

The increased risk of 30-day readmission was consistent across each group, with patients with ACS having the greatest risk, followed by those with AF and HF. The increase in hospital readmissions and ED visits may result from reduced access to both primary care physicians and cardiologists.[3] This is supported by previously published data from Jordan et al which explored the impact of residing in a rural area among older women from Queensland, Australia.[16] That study showed that females with suspected ischemic heart disease, HF, and AF were less likely to have had a cardiology review within the last 12 months.[16] Similarly, an American study demonstrated that one of the factors that influenced 30-day readmission in HF population was residing in a health professional shortage area.[14] Patients from rural locations were also more likely to be transferred to another acute care center prior to discharge.[10] The need for recurrent admission may also relate to rural patients being less likely to be on optimal-guided direct medical therapy, as previously shown in Australian women with HF.[17] The reasons are likely to be a complex

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TABLE 5 Logistic Regression for CVD 30-D Readmission, Heart Failure, Atrial Fibrillation, and Acute Coronary Syndrome

	Heart Failure		Atrial Fibrillation		Acute Coronary Syndrome	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Regional/remote	1.08 (1.00-1.17)	0.064	1.14 (1.04-1.25)	0.005	1.30 (1.21-1.40)	<0.001
Age						
<65 y	Ref	Ref	Ref	Ref	Ref	Ref
65-75 y	1.10 (0.88-1.17)	0.873	1.39 (1.22-1.59)	<0.001	1.29 (1.17-1.41)	<0.001
>75 y	1.08 (0.94-1.24)	0.300	1.64 (1.44-1.88)	<0.001	1.71 (1.54-1.89)	<0.001
Female	0.93 (0.85-1.01)	0.102	1.04 (0.94-1.14)	0.459	0.99 (0.92-1.07)	0.795
Aboriginal or Torres Strait Island	1.15 (0.92-1.42)	0.205	1.33 (1.04-1.68)	0.019	1.40 (1.21-1.62)	<0.001
Atherosclerosis	1.40 (1.00-1.94)	0.043	1.73 (0.98-2.92)	0.047	1.47 (1.06-1.99)	0.017
Hypertension	1.02 (0.93-1.11)	0.668	0.92 (0.84-1.02)	0.106	1.02 (0.95-1.10)	0.589
Renal disease	1.45 (1.32-1.60)	<0.001	1.76 (1.53-2.02)	<0.001	1.65 (1.48-1.84)	<0.001
Diabetes	0.95 (0.86-1.05)	0.337	1.04 (0.92-1.19)	0.523	1.20 (1.10-1.30)	<0.001
Respiratory disease	1.12 (1.02-1.23)	0.02	1.49 (1.30-1.70)	<0.001	1.26 (1.12-1.41)	<0.001
Anemia	1.37 (1.20-1.56)	<0.001	1.64 (1.30-2.06)	<0.001	1.60 (1.37-1.87)	<0.001
Obesity	0.81 (0.68-0.95)	0.010	1.13 (0.90-1.42)	0.287	1.00 (0.87-1.16)	0.948

The model was also adjusted for COVID-19 period, interaction with COVID-19 period, marital status, lipidemia, stroke, transient ischemic attacks, venous thromboembolism, fall, smoking, and alcohol use.
Abbreviation as in Table 1.

interplay between socioeconomic, geographic, and health care factors, which are not likely to be amenable to simple interventions.

On the other hand, the mortality outcomes observed in the HF and AF patients in our study are significantly different from the mortality outcomes observed in similar populations in the United States.[10-12] Published data from U.S. rural HF, AF, and ACS populations demonstrated higher mortality.[10-13] In our study, only ACS was associated with an increased risk of all-cause mortality in the rural and remote population when adjusting for demographics and comorbidities, with this increased risk greatest in the first 12 months. The reason for ACS having worse mortality (unlike HF and AF) may be due to limited access to timely ACS management among the rural population.[18] This has previously been shown with metropolitan ACS patients also being more likely to have higher rates of percutaneous coronary intervention and lower rates of interhospital transfer, with nearly 80% of rural patients requiring transfer.[18] This result is supported by a Canadian study, with patients

TABLE 6 Cox Proportional Hazard Survival for CVD Admissions, Heart Failure, Atrial Fibrillation, and Acute Coronary Syndrome

	Heart Failure		Atrial Fibrillation		Acute Coronary Syndrome	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Regional/remote	0.99 (0.96-1.03)	0.699	0.96 (0.91-1.00)	0.064	1.05 (1.01-1.09)	0.015
Age						
<65 y	Ref	Ref	Ref	Ref	Ref	Ref
65-75 y	1.68 (1.55-1.82)	<0.001	2.92 (2.65-3.22)	<0.001	2.95 (2.75-3.16)	<0.001
>75 y	3.30 (3.06-3.57)	<0.001	8.30 (7.55-9.13)	<0.001	8.41 (7.85-9.01)	<0.001
Female	0.88 (0.85-0.92)	<0.001	0.78 (0.75-0.83)	<0.001	0.91 (0.87-0.95)	<0.001
Aboriginal or Torres Strait Island	0.97 (0.87-1.09)	0.641	1.23 (1.06-1.43)	0.008	1.11 (1.00-1.24)	0.059
Atherosclerosis	1.57 (1.36-1.81)	<0.001	1.75 (1.36-2.26)	<0.001	1.66 (1.44-1.92)	<0.001
Hypertension	0.86 (0.82-0.89)	<0.001	0.96 (0.91-1.02)	0.17	0.89 (0.86-0.93)	<0.001
Renal disease	1.43 (1.37-1.49)	<0.001	1.67 (1.55-1.80)	<0.001	1.85 (1.75-1.95)	<0.001
Diabetes	1.05 (1.00-1.10)	0.03	1.18 (1.10-1.26)	<0.001	1.28 (1.22-1.34)	<0.001
Respiratory disease	1.14 (1.09-1.19)	<0.001	1.57 (1.45-1.69)	<0.001	1.62 (1.51-1.72)	<0.001
Anemia	1.21 (1.13-1.28)	<0.001	1.66 (1.48-1.86)	<0.001	1.51 (1.40-1.64)	<0.001
Obesity	0.90 (0.83-0.98)	0.012	0.90 (0.77-1.06)	0.211	1.04 (0.94-1.14)	0.450
Smoking	1.11 (1.04-1.19)	0.004	1.49 (1.36-1.64)	<0.001	1.17 (1.10-1.25)	<0.001

The model was also adjusted for COVID-19 period, interaction with COVID-19 period, marital status, lipidemia, stroke, transient ischemic attacks, venous thromboembolism, fall, smoking, and alcohol use.
Abbreviation as in Table 1.

from nonmetropolitan areas having increased risk of 1-year mortality.[19] Interestingly, this study found that there was no difference in mortality between nonmetropolitan and metropolitan patients when adjusting for clinical covariates and area income.[19] The disparity between studies from the United States and our study may be further related to the universal access to health care offered in Australia.[20]

There are noted challenges in rural health care internationally including local availability of staff, differing geography, funding arrangements, and different health systems, making a single solution unlikely. Well defined, evidence-based, effective, multidisciplinary care models to assess, monitor, and educate patients,[21-23] adapting and tailoring these models to a rural environment may offer a potential solution to improving rural health outcomes. Additionally, the increasing adoption and prevalence of telehealth models of care represent a potential way to enhance access to timely specialized care for regional, rural, and remote communities.[24]

Multidisciplinary models of care have shown demonstrable success in rural environments with support from tertiary-level hospitals: this may represent a viable model to support the provision of rural cardiology care.[25] Further studies which assess the models of care to most appropriately provide early postdischarge care and patient education to enhance the management of CVD and reduce health care expenditure, particularly from a regional context, may provide an important contribution in the care of rural cardiovascular patients and reduce burden on the hospital system.

STRENGTHS AND LIMITATIONS

Limitations of this study include the lack of ability to establish causation for the disparities in rural health care, and without the ability to control for other important confounders such as education, employment, income, and health literacy. This study is also limited in not being able to assess specific medical therapy provided for each patient or patients adherence to medication, and the patients' access to primary health care physicians, or general practitioners. These factors may impact the mortality and readmission rate disproportionately between both groups. This study was also dependent on coding, with its inherent limitations, although this would be expected to be evenly distributed among both groups.

The strengths of this study include the retrospective, large "real-world" patient population from a diverse area encompassing a quaternary metropolitan center and smaller rural centers, in conjunction with highly accurate mortality and readmission/representation data making the study unique and informative. The population within the area is a similar demographic to the overall Australian population and as such may be applicable in a range of jurisdictions and countries world-wide who have both metropolitan and rural patients.

CONCLUSIONS

Our study highlights the increased incidence of adverse cardiovascular events in a large geographical area, particularly with respect to presentations to ED and hospital readmissions, for those living in rural Australia. These data highlight the disparity in health care provided, and the ongoing need for interventions that may address poorer access to specialized health care in the early discharge phase of hospitalization. Our study suggests the need for ongoing strategies to mitigate the impact of avoidable readmission to hospital, to improve patient care, and reduce the burden on already stretched resources in rural areas. While the exact model remains yet to be described, the implementation of rural specific integrative multidisciplinary models of care may represent important steps to improve patient care.

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PERSPECTIVES

COMPETENCY IN SYSTEMS-BASED PRACTICE: Rural or remote patients with CVD have increased risk of 30-day readmission, increased number of readmissions, and increased number of ED presentations. This is however not associated with increased mortality. Discharge disposition needs to be considered for patients from rural or remote regions. Rural health care can be challenging and varies between regions, multidisciplinary care models, and telehealth models may offer a potential solution. More studies are required to elicit the optimal method of care to provide early postdischarge care and patient education to enhance the management of CVD and reduce health care expenditure.

TRANSLATIONAL OUTLOOK: This study highlights critical disparities in acute cardiac care outcomes for patients in rural and remote areas, emphasizing the urgent need for targeted interventions to enhance patient care. Specifically, the findings reveal that individuals presenting with HF, AF, and ACS in these regions experience higher rates of 30-day readmissions and ED visits,. Notably, the greatest risk of readmission was observed among ACS patients, followed by those with AF and HF. These insights underline the necessity for tailored healthcare strategies that address the unique challenges faced by rural populations. By focusing on enhancing access to care and resources in underserved areas, we can work towards reducing the burden of acute cardiac events and fostering a more equitable healthcare landscape.

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