Heart failure outcomes are worse for patients from rural areas in Western Australia

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-004724
Article Type:	Research
Date Submitted by the Author:	19-Dec-2013
Complete List of Authors:	Teng, Tiew-Hwa Katherine; The University of Western Australia, Combined Universities Centre for Rural Health Katzenellenbogen, Judith; The University of Western Australia, Combined Universities Centre for Rural Health Hung, Joseph; The University of Western Australia, Sir Charles Gairdner Hospital Unit, School of Medicine and Pharmacology Knuiman, Matthew; University of Western Australia, School of Population Health Sanfilippo, Frank; The University of Western Australia, School of Population Health Geelhoed, Elizabeth; The University of Western Australia, School of Population Health Hobbs, Michael; The University of Western Australia, School of Population Health Thompson, Sandra; The University of Western Australia, Combined Universities Centre for Rural Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health, Cardiovascular medicine
Keywords:	Heart failure < CARDIOLOGY, EPIDEMIOLOGY, Cardiology < INTERNAL MEDICINE

Heart failure outcomes are worse for patients from rural areas in Western Australia

Authors: Tiew-Hwa Katherine Teng[1], Judith M Katzenellenbogen[1], Joseph Hung[2], Matthew Knuiman[3], Frank M Sanfilippo[3], Elizabeth Geelhoed[3], Michael Hobbs,[3] Sandra C Thompson[1]

Affiliations:

1. Combined Universities Centre for Rural Health, University of Western Australia, Perth, WA, Australia.
2. Sir Charles Gairdner Hospital Unit, School of Medicine & Pharmacology, University of Western Australia, Perth, WA, Australia.
3. School of Population Health, University of Western Australia, Perth, WA, Australia.

Corresponding author:

Tiew-Hwa Katherine Teng (Dr)

Combined Universities Centre for Rural Health, School of Primary, Aboriginal and Rural Health the University of Western Australia, 35 Stirling Highway (M706), Crawley, WA 6009, Australia.

Email: katherine.teng@uwa.edu.au

Office Phone: +61 (8) 9346 2755

Office Fax: +61 (8) 9346 1665

Key words: heart failure, mortality, rural health, epidemiology

Word count: 2 818

Abstract

Background: Remoteness and variable access to health care can cause important disparities in outcomes following heart failure (HF) for metropolitan versus rural populations.

Objectives: We examined differentials in short-term (30-day mortality) and 1-year mortality (in 30-day survivors) following index (first-ever) hospitalisation for heart failure (HF), between rural and metropolitan patients resident in Western Australia (WA).

Design: A population-based cohort study.

Setting: Hospitalised patients in WA, Australia.

Participants: Index patients aged 20-84 years with a first-ever hospitalisation for HF between 2000 and 2009, using the WA linked-health data.

Main outcome measures: 30-day and 1-year all-cause mortality (in 30-day survivors) following index admission for HF.

Results: Of 17,379 index HF patients identified, 25.9% (4,499) were from rural areas. Rural patients were significantly younger at first HF hospitalisation than metropolitan patients. Aboriginal patients comprised 1.9% of metropolitan and 17.2% of rural patients. Despite some statistical differences, the prevalence of antecedents including ischaemic heart disease, hypertension, diabetes, and chronic kidney disease was high (>20%) in both subpopulations. The age, sex and calendar-year adjusted OR for 30-day mortality comparing rural to metropolitan patients was 1.16 (95% CI 1.01 – 1.33) and the HR for 1-year mortality was 1.11 (1.01 – 1.22). These relative risk estimates increased and remained significant after further progressive adjustments for Aboriginality, socio-economic status, insurance status, emergency presentation, comorbidities and revascularization with OR 1.25 (1.06 – 1.48) for 30-day mortality and HR 1.13 (1.02– 1.27) for one-year mortality.

Conclusions: Rural patients with HF in WA have poorer risk-adjusted outcomes compared to metropolitan patients. This finding has important implications for chronic disease management and provision of health services in rural Australia.

Article summary

Strengths and limitations of this study

- The strengths of this study lie in the quality and near complete ascertainment of the short and long-term mortality after first HF hospitalization using the Western Australia (WA) linked administrative data.
- A principal diagnosis of HF in the WA linked hospital morbidity data had been previously validated against the Boston diagnostic criteria with a positive predictive value of 92.4% for 'definite' HF.
- We found a higher risk-adjusted 30-day and 1-year mortality (in 30-day survivors) in rural (compared with metropolitan) patients following first HF hospitalisation in Western Australia between 2000 and 2009. The mortality disparity between rural and metropolitan patients persisted after adjustment for Aboriginality, other major socio-demographic differences and comorbidities.
- However, we do not have information to adjust for medications in our cohort and socio-deprivation was derived using an area-based measure which could give rise to potential misclassification.
- The findings have implications for enhancing chronic disease management and secondary prevention of HF in rural Western Australia.

Introduction

The management of chronic diseases is an increasing public health concern in rural areas.[1] Australians living in regional and remote areas generally have poorer health than metropolitan residents,[1] with higher rates of chronic diseases reported in these areas.[2] The health needs of many regional and remote communities have not been met,[3] despite many initiatives to address geographical inequalities over the last decade. Generally, rural populations experience poorer access to and limited availability of health and allied health care services with the provision of health care services inversely proportional to the distance from capital cities.[1]

Rural inhabitants have a constellation of risk factors and experience greater socio-economic disadvantage[4] which also affect people's need for and access to health services.[2] Any understanding of the rural dimension in health needs to be inclusive of Indigenous Australians as Aboriginal and Torres Strait Islander peoples are more likely to live in non-metropolitan areas.[5] Additionally, cardiovascular disease (CVD), including heart failure (HF), is a major cause of premature death in the Indigenous population in Australia.[6]

Heart failure is a chronic debilitating disease, with 50%-60% mortality within 5 years.[7] HF is a major cause of death from CVD and outcomes can be adversely affected by restricted access to hospital and continuing care as well as the standard of clinical management.[8] Therefore death rates from HF are a useful indicator of disparities in health access and care between rural and metropolitan patients. Previous studies from Canada [9, 10] suggest important disparities in the outcomes of HF among metropolitan versus rural populations. Although Canada has similarities in the universal health care system and geography as Australia, there are no previous studies (on HF) in the Australian context.

We examined differentials in short-term (30-day mortality) and 1-year mortality (in 30-day survivors) following index (first-ever) hospitalisation for HF, between rural and metropolitan patients resident in Western Australia.

Methodology

Study setting and data sources

The study was performed in Western Australia, which is the largest (by land mass) of six states in Australia, with a land mass spanning 2.53 million km^2. Based on the 2006 census, about 27% of the 2.5 million inhabitants in Western Australia lived in what is referred as regional and remote Australia. Western Australia is also home to the third largest number of Aboriginal Australians (13.2% of total Aboriginal population). Australia has a universal health care system with free public acute hospital services, while allowing choice through a mix of public and private health care service providers.

Data were obtained from the Western Australian Data Linkage System, a population-based electronic linked health database which has been used extensively for health-related research[11]. The Hospital Morbidity Data Collection (HMDC), a core dataset of the data linkage system, records information on hospital admissions throughout Western Australia (WA), and is regularly audited for quality and accuracy. HMDC data are routinely linked to the Mortality register using probabilistic matching with greater than 99% accuracy.[11]

Our study was a population-based cohort using linked health data comprising all WA residents aged 20-84 years who were admitted with a first hospitalisation for HF between 2000 and 2009, [with no previous admissions in the past ten years] as described previously.[12, 13] Inclusion in the study was based on a principal discharge diagnosis of HF or a secondary discharge diagnosis of HF with a principal discharge diagnosis of a cardiovascular condition, excluding

acute myocardial infarction (AMI). The coding for HF as a principal discharge diagnosis in the HMDC has been previously validated against the Boston diagnostic criteria with a positive predictive value of 92.4% for 'definite' HF.[14]

Ethics approvals were obtained from the WA Aboriginal Health Ethics Committee and Human Research Ethics Committees of the Department of Health Western Australia and The University of Western Australia.

Geographical classification

Using residential post codes, the Accessibility/Remoteness Index of Australia (ARIA) classification was used to define the five categories of residence based on road distance to service centres: major cities, inner regional, outer regional, remote and very remote.[15] For the regression analysis, place of residence was dichotomised into metropolitan residence (based on the greater Perth metropolitan city definition,[16] including urban and some of inner regional), and rural residence (remainder of inner regional, outer regional, remote and very remote). A sensitivity analysis was performed using three geographical locations: (i) metropolitan[16]; (ii) regional (remainder of inner regional and all of outer regional); and (iii) remote/very remote.

Socio-Economic Indices for Areas (SEIFA)[17], were assigned to each patient based on residential postcodes and divided into quintiles, based on pre-defined cut-points. The first quintile (Q1) represents the most disadvantaged group and fifth quintile (Q5) the least.

Comorbidities, interventions and procedures

Individual comorbidities within 5 years or concurrent with index HF hospitalization were identified: hypertension, atrial fibrillation, rheumatic fever and rheumatic heart disease, diabetes, valvular heart disease, chronic kidney disease, renal failure, chronic obstructive pulmonary

disease (COPD), unstable angina, AMI, other ischaemic heart disease (IHD), and cerebrovascular disease. A Charlson comorbidity score[18] was calculated for each index case by applying a fixed 5-year look-back period using the HMDC. We used the Dartmouth-Manitoba ICD code assignments[19] in calculating the Charlson score based on the original 17 Charlson comorbidities. Percutaneous coronary intervention or coronary artery bypass grafting (CABG) and coronary angiography were similarly identified.

Statistical analysis

Descriptive analyses were used to characterise differences in the socio-demographics, comorbidities, and interventions/procedures received between HF patients who reside in metropolitan compared to rural areas. Means and standard deviations were calculated for continuous variables whilst frequencies and proportions were derived for categorical data. The Pearson chi-squared test was used to test for differences in categorical variables and the t-test or Mann-Whitney test for continuous variables. Multivariable logistic regression was used to determine predictors of death within 30 days, with odds ratios (ORs) and their 95% CIs reported. Multivariable Cox regression was used to determine survival to 1 year in 30-day survivors and hazard ratios (HRs) and their 95% CIs reported. All patients admitted between 1 January 2000 and 30 November 2009 were included for 30-day survival analysis. For survival analysis to 1 year (from index admission), only patients admitted with their first HF between 2000 and 2008 were included.

Results

Table 1 shows the geographic and socio-demographic characteristics of patients with first HF hospitalisation living in metropolitan (n=12,880, 74.1%) and rural areas (n=4,499, 25.9%) between 2000 and 2009. A total of 33.6% of rural patients were from remote or very remote

areas and the remainder from regional areas. Rural compared with metropolitan patients were significantly younger at first HF hospitalisation (mean age: 68±13 vs 71±12 years, p<0.001), and more likely men (59.3 vs 57.2%, p=0.017). Aboriginal (including Torres Strait Islander) patients comprised 17.2% of rural cases vs 1.9% of metropolitan cases. About 75% of rural HF patients were seen at public rural regional or small district hospitals compared with less than 1% of metropolitan patients. Rural patients were less likely to have private health insurance compared to metropolitan patients (20.3% vs 32.6%, p<0.001). More than 50% of rural patients (vs 13.4% metropolitan patients) were in the two lowest quintiles (index of most disadvantage) of SEIFA, a proxy for socio-economic status.

A higher proportion of rural patients had a Charlson index of 1-2 although a small but significantly larger proportion of metropolitan patients (being older) scored >3 (Table 1). Despite some statistical differences between metropolitan and rural patients, there was a high prevalence of potential antecedent HF risk factors including ischaemic heart disease, hypertension, atrial fibrillation, diabetes, chronic kidney disease, COPD, cerebrovascular disease and rheumatic and non-rheumatic valvular heart disease in both subpopulations (see Table 1). Rates of coronary interventions (prior to or on index admissions) were low overall but significantly lower in rural patients. When adjusted for age, sex, period, Aboriginality and Charlson comorbidity index, rural patients with HF were less likely to have coronary angiography compared to metropolitan patients (risk-adjusted odds (OR)=0.81; 95% CI 0.77-0.86, p<0.001).

Crude 30-day and 1-year cumulative all-cause mortality and unadjusted risk were not significantly different between metropolitan and rural patients with first HF hospitalisation (Table 1, Table 2). After adjusting for age, sex and period, patients from rural areas had a higher risk of 30-day death (OR 1.16, 95% CI 1.01-1.33) and 1-year death in 30-day survivors (HR 1.11, 95%

CI 1.01-1.22) (see Table 2). The difference in survival between rural and metropolitan patients increased with further adjustment for Aboriginality, SEIFA (as proxy for socio-economic status), private insurance status, emergency presentation and the Charlson comorbidity index, with OR of 1.26 and HR of 1.14. The association between rurality and mortality persisted between the two subpopulations after further adjustment to include other individual comorbidities of interest, significant interaction effects and interventions (see Table 2).

No significant interactions were found between sex and rurality; Aboriginality and rurality (as location of residence). Further evaluation of mortality in men and women separately and in younger (<55 years) and older patients showed similar odds/hazards of death at 30 days and 1-year (in 30-day survivors) in rural patients compared with metropolitan patients.

A sensitivity analysis using three levels of geographical residence (metropolitan, regional and remote), indicates that regional patients had significantly higher adjusted 30-day and 1-year mortality (in 30-day survivors) than metropolitan patients (Table 3). However, the slightly higher OR for 30-day mortality in remote patients (1.29; 95% CI 0.98-1.69) did not reach significance in the fully adjusted model, and the adjusted HR for one-year mortality (in 30-day survivors) was not higher in remote patients (Table 3).

DISCUSSION

Heart failure is a complex, disabling, and potentially deadly clinical syndrome, of increasing public health importance as the population ages.[20] Our study examined hospitalised patients with ‘first-ever’ HF, and accordingly, a vast majority (>93%) were emergency presentations to hospital. In this population-based cohort of patients, we found that a sizeable minority of patients (26%) live in rural/remote WA. The majority of the rural patients with HF were from areas of social disadvantage with limited or no access to specialist services for HF, as others

have found.[21, 22] Rural area of residence was consistently associated with higher risk-adjusted odds and hazard of short-term mortality at 30 days and 1-year (in 30-day survivors) respectively, compared with metropolitan patients, even after controlling for socio-economic status, Aboriginality, private insurance status and risk factors. The same findings were observed in the subgroup analyses: both men and women who lived in rural/remote areas of WA; as well as in older patients aged 55 years and over.

Earlier research by Clark et al[23] showed a significantly higher prevalence of congestive HF in rural compared to metropolitan areas among patients aged 60 years and over. Furthermore, rates of echocardiography for diagnosis or specialist referrals and rate of prescribing angiotensin-converting enzyme inhibitor drugs were consistently lower in rural compared with metropolitan areas.[23] Different pharmacotherapy patterns in rural and metropolitan Canadian patients with HF have also been reported.[9] We found that uptake of coronary angiography or interventions were lower in rural patients, consistent with the previous findings,[10, 23] although disparity in discharge medications was not examined in our study.

Western Australia is geographically large, being the size of Western Europe, with much of its area sparsely populated. Accordingly, the tyranny of distance and lack of transport (as the interface between different entry points to the health care system) are major obstacles to accessing appropriate health care for rural West Australians. Access to appropriate specialist expertise also requires transfer between services and there are many reasons why such transfers may not occur. Moreover, there may be limited access to comprehensive primary health care services, poor integration between different levels of care and inadequate services to support ongoing home-based intervention and HF self-management[24] , HF-specific cardiac rehabilitation programs[25] and socio-culturally appropriate services.[26-28] Hence, the dimension of metro-rural divide in the context of Western Australia is larger than that which

occurs in other states.[29] Issues of rural and remote health are much more complex than merely the practice of health in another location[3] and are affected by issues such as workforce shortages and retention of healthcare workers, higher out-of-pocket costs and the time and cost of travel.[3]

Rural and remote patients with HF differed considerably from metropolitan patients including being younger, more socially disadvantaged and more likely to be Aboriginal. Despite Australia having universal health insurance through Medicare which allows free access to public hospital treatment and outpatient medical consultations and medications being subsidised, there remain barriers to specialist consultations for socially disadvantaged groups, particularly where upfront cash payments are required. An even more important disparity is the paucity of specialist cardiology care in regional/remote areas. Evidence shows that increasing private health insurance coverage in Australia has been associated with loss of equity after controlling for other factors.[29, 30]

Our results showed that despite further adjustments for demographics, SEIFA and private health insurance status (both as a proxy for socio-economic status), Aboriginality, emergency presentations, individual comorbidities and interventions, differential difference in mortality outcomes persisted for rural patients compared to metropolitan patients. It is plausible that the type of care received from regional, small district hospitals and/or rural primary care providers compared with metropolitan hospitals and urban general practices has a differential impact on mortality. Around 75% of the rural patients were managed at regional, small district hospitals, while a vast majority of urban patients were treated in tertiary and private hospitals. There might be another reason why fewer people have private insurance in rural areas – because there are only 2 private hospitals in rural areas, and going in as a private patient in a public rural hospital

offers little advantage. Hence, rural residents may not see a need for private insurance, and they probably think the likelihood of being admitted to a metro private hospital is low.

In the sensitivity analysis with the three levels for residential location, regional patients showed increased risk-adjusted ORs/HRs of 30-day mortality and 1-year mortality (in 30-day survivors). The association for remote/very remote patients was marginally significant (for 30-day mortality) possibly because of a lack of power. However, previous work by Katzenellenbogen et al[31] found that some older groups living in remote areas had lower MI rates than metropolitan residents, suggesting a possible migration effect of remote patients with heart disease moving to regional/metro centres. The data from the current study may reflect such a phenomenon, with remote HF patients moving to more accessible centres after their incident event and thus benefiting through improved 1-year survival.

Our results are consistent with other studies from Canada and the US which also reported worse outcomes in rural versus metropolitan patients with HF,[8-10] The same rural-metropolitan differential in WA was reported for the incidence of myocardial infarction in Western Australia.[31] However, conflicting evidence was reported from a CVD risk study on South-West Victoria and North-West Adelaide, Australia.[29] That study examined cardiovascular mortality rates without comprehensive adjustment and only a small proportion of the patients examined were Aboriginal.[29] There is also a contextual difference in that HF has high mortality with patients often presenting with heavy comorbidity burden.

The strengths of this study lie in the quality and near complete ascertainment of the short- and long-term mortality after first HF hospitalization using linked administrative data in Western Australia,[11] and the previous validation with respect to a principal diagnosis of HF.[14] However, socio-deprivation was derived using an area-based measure which gives rise to

potential misclassification at an individual level. We have no information as to why people choose not to have private health insurance. Our study also lacked information on use of medications in our cohort.

Conclusions

This study highlights the impact of geographical or spatial isolation on mortality outcomes in HF patients as the first step in understanding rural-urban differences. From the health policy perspective, the higher rural mortality likely points to the inequalities in the availability and access to appropriate medical care, rather than compositional differences in rural and metropolitan patients with HF. Rural Western Australia is not homogeneous and the proportion of Aboriginal people increases with remoteness. This has implications for the provision of collaborative models of care for chronic disease management and secondary prevention of HF in rural areas.

Table 1. Baseline characteristics and crude mortality of metropolitan vs rural patients with a 'first-ever' (index) admission for heart failure between 2000 and 2009.

Description	Metropolitan, n (%)	Rural, n (%)	P-value
Cases by ARIA classification[15]			
• Major city	9,006 (69.9)		
• Inner Regional	3,874 (30.1)	1,182 (26.3)	
• Outer Regional		1,807 (40.2)	
• Remote		477 (10.6)	
• Very Remote		1,033 (23.0)	
Total Cases	12,880 (74.1)	4,499 (25.9)	
Women, n (%)	5,511 (42.8)	1,833 (40.7)	0.017
Mean age ±SD (years)	70.8±11.7	67.5±13.4	<0.001
Age groups, n (%)			
• 20-34 years	167 (1.3)	117 (2.6)	<0.001
• 35-49 years	655 (5.1)	382 (8.5)	
• 50-64 years	2,294 (17.8)	1,039 (23.1)	
• 65-84 years	9,764 (75.8)	2,961 (65.8)	
Aboriginal patients, n (%)	241 (1.9)	772 (17.2)	<0.001
Length of stay, mean days ± SD	7.1±8.6	6.4±15.8	0.001
Hospital type			
• Metro tertiary/teaching	7,212 (56.0)	543 (12.1)	<0.001 for all
• Metro/non-teaching	1,282 (10.0)	28 (0.6)	
• Rural regional	48 (0.4)	1,524 (33.9)	
• Rural district/small	58 (0.5)	1,835 (40.8)	
• Private	4,280 (33.2)	569 (12.7)	
Emergency admission, n(%)	12,095 (93.9)	4,265 (94.8)	0.028
Private health insurance, n(%)	4,197 (32.6)	915 (20.3)	<0.001
SEIFA (socio-economic status), n(%)			
• 1st quintile (most disadvantaged)	3 (0.2)	1,182 (26.5)	<0.001 for all
• 2nd quintile	1,693 (13.2)	1,085 (24.3)	
• 3rd quintile	4,827 (37.4)	1,476 (33.1)	
• 4th quintile	2,918 (22.6)	631 (14.1)	
• 5th quintile (least disadvantaged)	3,439 (26.6)	89 (2.0)	
Comorbidities, n (%) *			
All ischaemic heart disease †	6,426 (49.9)	1,895 (42.1)	0.001
Acute myocardial infarction	2,242 (17.4)	636 (14.1)	<0.001
Unstable angina	1,987 (15.4)	485 (10.8)	<0.001

Hypertension	7,194 (55.9)	2,408 (53.5)	0.007
Atrial fibrillation	5,579 (43.3)	1,692 (37.6)	<0.001
Diabetes	4,104 (31.9)	1,543 (34.3)	0.003
Chronic kidney disease	2,851 (22.1)	918 (20.4)	0.015
Renal failure	415 (3.2)	181 (4.0)	0.012
COPD	2,600 (20.2)	1,146 (25.5)	<0.001
Cerebrovascular disease	1,404 (10.9)	391 (8.7)	<0.001
Rheumatic heart disease/rheumatic valvular heart disease	1,868 (14.5)	526 (11.7)	<0.001
Valvular heart disease, non-rheumatic	2,663 (20.7)	703 (15.6)	<0.001
Interventions, n (%)			
History of PCI	779 (6.1)	203 (4.5)	<0.001
History of CABG	342 (2.7)	118 (2.6)	0.891
Index PCI	228 (1.8)	36 (0.8)	<0.001
Index CABG	374 (2.9)	86 (1.9)	<0.001
Coronary angiography	6,003 (46.6)	1,711 (38.0)	<0.001
Charlson Index n (%)			
0	73 (0.6)	32 (0.7)	
1-2	5,780 (44.9)	2,158 (48.0)	0.001 for all
3-4	3,474 (27.0)	1,164 (25.9)	
>4	3,553 (27.6)	1,145 (25.4)	
Crude cumulative mortality			
30-day case fatality**	838 (6.6)	306 (6.9)	0.474
1-year mortality***	2,364 (20.5)	829 (20.7)	0.799

Continuous variables expressed as mean ± SD. Categorical variables expressed as proportions, n (%).
P-value is for difference between Metro and rural patients
* Patients could have multiple comorbidities.
† All ischaemic heart disease includes acute myocardial infarction.
PCI – percutaneous coronary intervention
CABG – coronary artery bypass graft
** Patients admitted in December 2009 were excluded from analysis
*** Year 2009 was used as a follow-up period.

Table 2. Step-wise risk adjustment for 30-day mortality and 1-year mortality (in 30-day survivors) in rural patients with index heart failure vs metropolitan patients.

Risk adjustment	Odds ratio [(OR), 95% CI]	p-value
Death at 30 days from index admission		
Unadjusted	1.05 (0.92-1.20)	0.487
Adjusted for:		
1. Age, sex, period	1.16 (1.01-1.33)	0.036
2. Model 1 + Aboriginality, SEIFA, private insurance, emergency presentation, Charlson index	1.26 (1.07-1.49)	0.005
3. Model 2 + individual comorbidities, interactions, insurance status, emergency presentation	1.26 (1.07-1.48)	0.007
4. Model 3 + PCI/CABG	1.25 (1.06-1.48)	0.007
Death at 1-year in 30-day survivors	**Hazard ratio [(HR), 95% CI]**	**p-value**
Unadjusted	0.99 (0.90-1.09)	0.866
Adjusted for		
1. Age, sex, period	1.11 (1.01-1.22)	0.037
2. Model 1 + Aboriginality, SEIFA, private insurance, emergency presentation, Charlson index	1.14 (1.02-1.29)	0.030
3. Model 2 + individual comorbidities, interactions	1.14 (1.02-1.28)	0.032
4. Model 3 + PCI/CABG	1.13 (1.02-1.27)	0.040

Table 3. Sensitivity analysis showing step-wise risk adjustment for 30-day mortality and 1-year mortality (in 30-day survivors) in patients with index heart failure by level of residential location

Risk-adjustment	Regional WA		Remote/very remote WA	
Death at 30-day from index admission†	**Odds ratio (95% CI)**	**p-value**	**Odds ratio (95% CI)**	**p-value**
• Unadjusted	1.10 (0.94-1.29)	0.227	0.95 (0.76-1.19)	0.649
Adjusted for:				
1. Age, sex & period	1.12 (0.96-1.31)	0.143	1.25 (0.99-1.57)	0.058
2. Model 1 + Aboriginality, SEIFA, private insurance, emergency presentation, Charlson index	1.24 (1.04-1.48)	0.015	1.34 (1.02-1.75)	0.033
3. Model 2 + individual comorbidities, interactions	1.25 (1.04-1.49)	0.014	1.28 (0.98-1.68)	0.069
4. Model 3 + PCI/CABG	1.24 (1.04-1.48)	0.016	1.29 (0.98-1.69)	0.071
Death at 1-year in 30-day survivors†				
• Unadjusted	1.09 (0.97-1.21)	0.136	0.81 (0.68-0.95)	0.011
Adjusted for:				
1. Age, sex & period	1.13 (1.01-1.26)	0.034	1.07 (0.90-1.26)	0.457
2. Model 1 + Aboriginality, SEIFA, private insurance, emergency presentation, Charlson index	1.17 (1.03-1.32)	0.014	1.03 (0.85-126)	0.747
3. Model 2 + individual comorbidities, interactions	1.18 (1.04-1.33)	0.010	1.02 (0.84-1.24)	0.878
4. Model 3 + PCI/CABG	1.17 (1.03-1.32)	0.014	1.02 (0.84-1.24)	0.870

† Patients with metropolitan residence as the reference group.

Acknowledgements

The authors thank the Western Australian Data Linkage Branch and the staff of the Inpatient Data Collections for the provision of the data and the Registry of Births, Deaths and Marriages for providing the death data.

Competing interests: none declared

Authors contribution: All authors critically reviewed and contributed to the intellectual content of the manuscript. THKT, JMK, MK, SCT and JH were involved with the conception of the study. THKT performed the statistical analyses, supported by MK and drafted the manuscript. SCT, JH and MH provided the clinical expertise. All authors have read and approved the final version of the manuscript.

Extra data is available by emailing Tiew-Hwa Katherine Teng at katherine.teng@uwa.edu.au

Funding

The study had been supported by an NHMRC project grant (#1031057). J Katzenellenbogen is funded by an NHMRC Early Career Fellowship (#037429). The Combined Universities Centre for Rural Health receives funding from the Department of Health and Ageing.

REFERENCES

1. Australian Institute of Health and Welfare. Rural, regional and remote health - Indicators of health. Canberra, AIHW, 2005. Cat. No. PHE 59.

2. AIHW 2010. Cardiovascular medicines and primary health care: a regional analysis. Canberra: AIHW, 2010.

3. Wakerman J, Humphreys JS. Rural health: why it matters. *Med J Aust*. 2002;**176**:457-8.

4. Dixon J, Welch N. Researching the rural-metropolitan health differential using the 'social determinants of health'. *Aust J Rural Health*. 2000;**8**:254-60.

5. Australian Bureau of Statistics. Population distribution, Aboriginal and Torres Strait Islander Australians, 2006. ABS, 2007 Cat. no. 3238.0.55.001.

6. Humphreys J, Hegney D, Lipscombe J, et al. Whither rural health? Reviewing a decade of progress in rural health. *Aust J Rural Health*. 2002;**10**:2-14.

7. Levy D, Kenchaiah S, Larson MG et al. Long-term trends in the incidence of and survival with heart failure. *N Engl J Med*. 2002;**347**:1397-402.

8. Muus KJ, Knudson A, Klug MG et al. Effect of post-discharge follow-up care on re-admissions among US veterans with congestive heart failure: a rural-urban comparison. *Rural Remote Health*. 2010;**10**:1447.

9. Gamble JM, Eurich DT, Ezekowitz JA, et al. Patterns of care and outcomes differ for urban versus rural patients with newly diagnosed heart failure, even in a universal healthcare system. *Circ Heart Fail*. 2011;**4**:317-23.

10. Jin Y, Quan H, Cujec B, et al. Rural and urban outcomes after hospitalization for congestive heart failure in Alberta, Canada. *J Card Fail*. 2003;**9**:278-85.

11. Holman CD, Bass AJ, Rosman DL, et al. A decade of data linkage in Western Australia: strategic design, applications and benefits of the WA data linkage system. *Aust Health Rev*. 2008;**32**:766-77.

12. Teng TH, Finn J, Hobbs M et al. Heart failure: incidence, case fatality, and hospitalization rates in Western Australia between 1990 and 2005. *Circ Heart Fail*. 2010;**3**:236-43.

13. Teng TH, Katzenellenbogen JM, Thompson SC et al. Incidence of first heart failure hospitalization and outcomes in Aboriginal and non-Aboriginal patients in Western Australia, 2000-2009. (In-press). 2013.

14. Teng T-H, Finn J, Hung J et al. A Validation Study: How Effective is The Hospital Morbidity Data as a Surveillance Tool for Heart Failure in Western Australia? *Aus NZ J Public Health*. 2008;**32**:405-7.

15. Australian Institute of Health and Welfare. Rural, regional and remote health: a guide to remoteness classification. Canberra, ACT: 2004. Cat no. PHE 53.

16. Geographic Information Systems EB, Public Health Division,. Department of Health Health Geographical Classification, Version 4.0. I Perth: Department of Health, WA; 2013.

17. Australian Bureau of Statistics. Information paper: census of population and housing - socio-economic indexes for areas, Australia. Canberra: ABS, 2003. Cat no. 2033.055.001.

18. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;**40**:373-83.

19. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *J Clin Epidemiol*. 1993;**46**:1075-9.

20. Krum H, Jelinek MV, Stewart S, et al. Guidelines for the prevention, detection and management of people with chronic heart failure in Australia 2006. *Med J Aust*. 2006;**185**:549-57.

21. Wakerman J, Humphreys JS, Wells RW, et al. Improving rural and remote health. *Med J Aust.* 2007;**186**:486.

22. Unger CC, Warren N, Canway R, et al. Type 2 diabetes, cardiovascular disease and the utilisation of primary care in urban and regional settings. *Rural Remote Health*. 2011;**11**:1795.

23. Clark RA, Eckert KA, Stewart S, et al. Rural and urban differentials in primary care management of chronic heart failure: new data from the CASE study. *Med J Aust*. 2007;**186**:441-5.

24. Stewart S, Pearson S, Horowitz JD. Effects of a home-based intervention among patients with congestive heart failure discharged from acute hospital care. *Arch Intern Med*. 1998;**158**:1067-72.

25. Davidson PM, Cockburn J, Newton PJ, et al. Can a heart failure-specific cardiac rehabilitation program decrease hospitalizations and improve outcomes in high-risk patients? *Eur J Cardiovasc Prev Rehabil*. 2010;**17**:393-402.

26. Digiacomo M, Davidson PM, Taylor KP, et al. Health information system linkage and coordination are critical for increasing access to secondary prevention in Aboriginal health: a qualitative study. *Quality in Primary Care*. 2010;**18**:17-26.

27. DiGiacomo ML, Thompson SC, Smith JS, et al. 'I don't know why they don't come': barriers to participation in cardiac rehabilitation. *Aust Health Rev*. 2010;**34**:452-7.

28. Thompson SC, Digiacomo ML, Smith JS, et al. Are the processes recommended by the NHMRC for improving Cardiac Rehabilitation (CR) for Aboriginal and Torres Strait Islander

people being implemented?: an assessment of CR Services across Western Australia. *Australia and New Zealand Health Policy*. 2009;**6**:29.

29. Tideman P, Taylor AW, Janus E, et al. A comparison of Australian rural and metropolitan cardiovascular risk and mortality: the Greater Green Triangle and North West Adelaide population surveys. *BMJ open*. 2013;**3**:e003203.

30. Hindle D, McAuley I. The effects of increased private health insurance: a review of the evidence. *Aust Health Rev*. 2004;**28**:119-38.

31. Katzenellenbogen JM, Sanfilippo FM, Hobbs MS et al. Complex impact of remoteness on the incidence of myocardial infarction in Aboriginal and non-Aboriginal people in Western Australia. *Aust J Rural Health*. 2012;**20**:305-11.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Reported on page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	No
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6-8
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	All participants have first-ever heart failure hospitalisation
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	6, 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8, 10
		(*b*) Describe any methods used to examine subgroups and interactions	8, 10
		(*c*) Explain how missing data were addressed	16, 17
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods	No, loss to follow-up is minimal from previous studies done

taking account of sampling strategy	
(*e*) Describe any sensitivity analyses	Yes, page 10

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Rural-urban differentials in 30-day and 1-year mortality following first-ever heart failure hospitalisation in Western Australia: A population-based study using data linkage

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-004724.R1
Article Type:	Research
Date Submitted by the Author:	31-Mar-2014
Complete List of Authors:	Teng, Tiew-Hwa Katherine; The University of Western Australia, Western Australian Centre for Rural Health Katzenellenbogen, Judith; The University of Western Australia, Western Australian Centre for Rural Health Hung, Joseph; The University of Western Australia, Sir Charles Gairdner Hospital Unit, School of Medicine and Pharmacology Knuiman, Matthew; University of Western Australia, School of Population Health Sanfilippo, Frank; The University of Western Australia, School of Population Health Geelhoed, Elizabeth; The University of Western Australia, School of Population Health Hobbs, Michael; The University of Western Australia, School of Population Health Thompson, Sandra; The University of Western Australia, Western Australian Centre for Rural Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health, Cardiovascular medicine
Keywords:	Heart failure < CARDIOLOGY, EPIDEMIOLOGY, Cardiology < INTERNAL MEDICINE

Rural-urban differentials in 30-day and 1-year mortality following first-ever heart failure hospitalisation in Western Australia: A population-based study using data linkage

Authors: Tiew-Hwa Katherine Teng[1], Judith M Katzenellenbogen[1], Joseph Hung[2], Matthew Knuiman[3], Frank M Sanfilippo[3], Elizabeth Geelhoed[3], Michael Hobbs,[3] Sandra C Thompson[1]

Affiliations:

1. Western Australian Centre for Rural Health, University of Western Australia, Perth, WA, Australia.
2. Sir Charles Gairdner Hospital Unit, School of Medicine & Pharmacology, University of Western Australia, Perth, WA, Australia.
3. School of Population Health, University of Western Australia, Perth, WA, Australia.

Corresponding author:

Tiew-Hwa Katherine Teng (Dr)

Western Australian Centre for Rural Health, School of Primary, Aboriginal and Rural Health the University of Western Australia, 35 Stirling Highway (M706), Crawley, WA 6009, Australia.

Email: katherine.teng@uwa.edu.au

Office Phone: +61 (8) 9346 2755

Office Fax: +61 (8) 9346 1665

Key words: heart failure, mortality, rural health, epidemiology

Word count: 3,265

Abstract

Objectives: We examined differentials in short-term (30-day mortality) and 1-year mortality (in 30-day survivors) following index (first-ever) hospitalisation for heart failure (HF), between rural and metropolitan patients resident in Western Australia (WA).

Design: A population-based cohort study.

Setting: Hospitalised patients in WA, Australia.

Participants: Index patients aged 20-84 years with a first-ever hospitalisation for HF between 2000 and 2009 (with no prior admissions for HF in previous ten years), identified using the WA linked-health data.

Main outcome measures: 30-day and 1-year all-cause mortality (in 30-day survivors) following index admission for HF.

Results: Of 17,379 index HF patients identified, 25.9% (4,499) were from rural areas. Rural patients were significantly younger at first HF hospitalisation than metropolitan patients. Aboriginal patients comprised 1.9% of metropolitan and 17.2% of rural patients. Despite some statistical differences, the prevalence of antecedents including ischaemic heart disease, hypertension, diabetes, and chronic kidney disease was high (>20%) in both subpopulations. After adjusting for age only, patients from rural areas had a higher risk of 30-day death [OR 1.16 (95% CI 1.01-1.33)] and 1-year death in 30-day survivors [HR 1.11 (95% CI 1.01-1.23)]. These relative risk estimates increased and remained significant after further progressive adjustments for Aboriginality, socio-economic status, insurance status, emergency presentation, individual comorbidities and revascularization with OR 1.25 (1.06 – 1.48) for 30-day mortality and HR 1.13 (1.02– 1.27) for one-year mortality. The addition of the weighted Charlson index to the 30-day model improved the ‘c’ statistic (under the ROC curve) from 0.656 (using a variation of administrative claims model) to 0.714.

Conclusions: Remoteness and variable access to health care can cause important disparities in health outcomes. Rural patients with HF in WA have poorer risk-adjusted outcomes compared to metropolitan patients. This finding has important implications for chronic disease management and provision of health services in rural Australia.

Article summary

Strengths and limitations of this study

- The strengths of this study lie in the quality and near complete ascertainment of the short and long-term mortality after first HF hospitalization using the Western Australia (WA) linked administrative data.
- A principal diagnosis of HF in the WA linked hospital morbidity data had been previously validated against the Boston diagnostic criteria with a positive predictive value of 92.4% for 'definite' HF.
- We found a higher risk-adjusted 30-day and 1-year mortality (in 30-day survivors) in rural (compared with metropolitan) patients following first HF hospitalisation in Western Australia between 2000 and 2009. The mortality disparity between rural and metropolitan patients persisted after adjustment for Aboriginality, other major socio-demographic differences and comorbidities.
- However, we do not have information to adjust for medications in our cohort and socio-deprivation was derived using an area-based measure which could give rise to potential misclassification.
- The findings have implications for enhancing chronic disease management and secondary prevention of HF in rural Western Australia.

Introduction

The management of chronic diseases is an increasing public health concern in rural areas.[1] Australians living in regional and remote areas generally have poorer health than metropolitan residents,[1] with higher rates of chronic diseases reported in these areas.[2] The health needs of many regional and remote communities have not been met,[3] despite many initiatives to address geographical inequalities over the last decade. Generally, rural populations experience poorer access to and limited availability of health and allied health care services with the provision of health care services inversely proportional to the distance from capital cities.[1]

Rural inhabitants have a constellation of risk factors and experience greater socio-economic disadvantage[4] which also affect people's need for and access to health services.[2] Any understanding of the rural dimension in health needs to be inclusive of Indigenous Australians as Aboriginal and Torres Strait Islander peoples are more likely to live in non-metropolitan areas.[5] Additionally, cardiovascular disease (CVD), including heart failure (HF), is a major cause of premature death in the Indigenous population in Australia.[6]

Heart failure is a chronic debilitating disease, with 50%-60% mortality within 5 years.[7] HF is a major cause of death from CVD and outcomes can be adversely affected by restricted access to hospital and continuing care as well as the standard of clinical management.[8] Therefore death rates from HF are a useful indicator of disparities in health access and care between rural and metropolitan patients. Previous studies from Canada [9, 10] suggest important disparities in the outcomes of HF among metropolitan versus rural populations. Although Canada has similarities in the universal health care system and geography as Australia, there are no previous studies (on HF) in the Australian context.

We examined differentials in 30-day mortality and 1-year mortality (in 30-day survivors) following index (first-ever) hospitalisation for HF, between rural and metropolitan patients resident in Western Australia.

Methodology

Study setting and data sources

The study was performed in Western Australia, which is geographically the largest of six states in Australia, with a land mass spanning 2.53 million km^2. Based on the 2006 census, about 27% of the 2.5 million inhabitants in Western Australia lived in what is referred as regional and remote Australia. Western Australia is also home to the third largest number of Aboriginal Australians (13.2% of total Aboriginal population). Australia has a universal health care system with free public acute hospital services, while allowing choice through a mix of public and private health care service providers.

Data were obtained from the Western Australian Data Linkage System, a population-based electronic linked health database which has been used extensively for health-related research[11]. The Hospital Morbidity Data Collection (HMDC), a core dataset of the data linkage system, records information on hospital admissions throughout Western Australia (WA), and is regularly audited for quality and accuracy. HMDC data are routinely linked to the Mortality register using probabilistic matching with greater than 99% accuracy.[11]

The Emergency Department data Collection (EDDC) containing data on emergency department (ED) activity in Western Australia's public and private hospitals (under contract with the WA Government) was used to examine re-presentations to ED within 1-year of follow-up from index admission of HF.

Ours was a population-based cohort study using linked health data comprising all WA residents aged 20-84 years who were admitted with a first hospitalisation for HF between 2000 and 2009, [with no previous admissions in the past ten years] as described previously.[12, 13] Inclusion in the study was based on a principal discharge diagnosis of HF or a secondary discharge diagnosis of HF with a principal discharge diagnosis of a cardiovascular condition, excluding acute myocardial infarction (AMI). The coding for HF as a principal discharge diagnosis in the HMDC has been previously validated against the Boston diagnostic criteria with a positive predictive value of 92.4% for 'definite' HF.[14]

Ethics approvals were obtained from the WA Aboriginal Health Ethics Committee and Human Research Ethics Committees of the Department of Health Western Australia and The University of Western Australia.

Geographical classification

Using residential post codes, the Accessibility/Remoteness Index of Australia (ARIA) classification was used to define the five categories of residence based on road distance to service centres: major cities, inner regional, outer regional, remote and very remote.[15] For the regression analysis, place of residence was dichotomised into metropolitan residence (based on the greater Perth metropolitan city definition,[16] including urban and some of inner regional), and rural residence (remainder of inner regional, outer regional, remote and very remote). A sensitivity analysis was performed using three geographical locations: (i) metropolitan[16]; (ii) regional (remainder of inner regional and all of outer regional); and (iii) remote/very remote.

Socio-Economic Indices for Areas (SEIFA)[17], were assigned to each patient based on residential postcodes and divided into quintiles, based on pre-defined cut-points. The first quintile (Q1) represents the most disadvantaged group and fifth quintile (Q5) the least.

Comorbidities, interventions and procedures

Individual comorbidities within 5 years or concurrent with index HF hospitalization were identified: hypertension, atrial fibrillation, rheumatic fever and rheumatic heart disease, diabetes, valvular heart disease, chronic kidney disease, renal failure, chronic obstructive pulmonary disease (COPD), unstable angina, AMI, other ischaemic heart disease (IHD), and cerebrovascular disease. A Charlson comorbidity score [18] was calculated for each index case by applying a fixed 5-year look-back period using the HMDC. We used the Dartmouth-Manitoba ICD code assignments [19] in calculating the Charlson score based on the original 17 Charlson comorbidities. Percutaneous coronary intervention or coronary artery bypass grafting (CABG) and coronary angiography were similarly identified.

Statistical analysis

Descriptive analyses were used to characterise differences in the socio-demographics, comorbidities, and interventions/procedures received between HF patients who reside in metropolitan compared to rural areas. Means and standard deviations were calculated for continuous variables whilst frequencies and proportions were derived for categorical data. The Pearson chi-squared test was used to test for differences in categorical variables and the t-test or Mann-Whitney test for continuous variables. Multivariable logistic regression was used to determine predictors of death within 30 days, with odds ratios (ORs) and their 95% CIs reported. Multivariable Cox regression was used to determine survival to 1 year in 30-day survivors and hazard ratios (HRs) and their 95% CIs reported. All patients admitted between 1 January 2000 and 30 November 2009 were included for 30-day survival analysis. For survival analysis to 1 year (from index admission), only patients admitted with their first HF between 2000 and 2008 were included.

Adjustment for cluster correlation with postcode as the cluster was examined and found to have a non-significant effect and hence not included in the final models.

Results

Table 1 shows the geographic and socio-demographic characteristics of patients with first HF hospitalisation living in metropolitan (n=12,880, 74.1%) and rural areas (n=4,499, 25.9%) between 2000 and 2009. A total of 33.6% of rural patients were from remote or very remote areas and the remainder from regional areas. Rural compared with metropolitan patients were significantly younger at first HF hospitalisation (mean age: 68±13 vs 71±12 years, p<0.001), and more likely men (59.3 vs 57.2%, p=0.017). Aboriginal (including Torres Strait Islander) patients comprised 17.2% of rural cases vs 1.9% of metropolitan cases. About 75% of rural HF patients were seen at public regional or small district hospitals compared with less than 1% of metropolitan patients. Rural patients were less likely to have private health insurance compared to metropolitan patients (20.3% vs 32.6%, p<0.001). More than 50% of rural patients (versus 13.4% metropolitan patients) were in the two lowest quintiles (index of most disadvantage) of SEIFA, a proxy for socio-economic status.

Profile of care prior to the index hospitalisation for HF and pre-hospital emergency medical service (EMS) coverage by ambulance was different in both sub-populations (Table 1). Metropolitan (versus rural) patients were more likely to be managed by specialist clinicians (25.2% vs 15.1% rural); by contrast, more rural patients were cared for by GPs (18.4% versus 4.9% metropolitan). Metropolitan (versus rural) patients were more likely to be transported by EMS ambulance to admitting hospitals (38.5% versus 19.4%). About 65% of rural patients depended on private/public transport to get to admitting hospitals. Notably, rural (versus metropolitan) patients were also more likely (49.1% versus 20.4%) to present to EDs (for any condition) with tri-age scores of 4 or 5 (for semi-urgent or non-urgent cases) during the 1-year

follow-up, suggesting EDs being used to fill the gaps in primary care or specialist services in rural areas.

A higher proportion of rural patients had a Charlson index of 1-2 although a small but significantly larger proportion of metropolitan patients (being older) scored >3 (Table 1). Despite some statistical differences between metropolitan and rural patients, there was a high prevalence of potential antecedent HF risk factors including ischaemic heart disease, hypertension, atrial fibrillation, diabetes, chronic kidney disease, COPD, cerebrovascular disease and rheumatic and non-rheumatic valvular heart disease in both subpopulations (see Table 1). Rates of coronary interventions (prior to or on index admissions) were low overall but significantly lower in rural patients. When adjusted for age, sex, period, Aboriginality and Charlson comorbidity index, rural patients with HF were less likely to have coronary angiography compared to metropolitan patients (risk-adjusted odds (OR)=0.81; 95% CI 0.77-0.86, p<0.001).

Crude 30-day and 1-year cumulative all-cause mortality and unadjusted risk were not significantly different between metropolitan and rural patients with first HF hospitalisation (Table 1, Table 2). After age adjustment only, patients from rural areas had a higher risk of 30-day death [OR 1.16 (95% CI 1.01-1.33)] and 1-year death in 30-day survivors [HR 1.11 (95% CI 1.01-1.23), see Table 2]. The difference in survival between rural and metropolitan patients increased with further adjustment for socio-demographic differences including Aboriginality, SEIFA (as proxy for socio-economic status), private insurance status, emergency presentation, and the Charlson comorbidity index, with OR of 1.26 and HR of 1.14. The association between rurality and mortality persisted between the two subpopulations after further adjustment to include other individual comorbidities of interest, significant interaction effects and interventions (see Table 2). The addition of the weighted Charlson index to the 30-day model (using a

variation of the administrative claims model[20] improved the 'c' statistic (under the ROC curve) from 0.656 to 0.714.

No significant interactions were found between sex and rurality; Aboriginality and rurality (as location of residence). Further evaluation of mortality in men and women separately and in younger (<55 years) and older patients showed similar odds/hazards of death at 30 days and 1-year (in 30-day survivors) in rural patients compared with metropolitan patients.

A sensitivity analysis using three levels of geographical residence (metropolitan, regional and remote), indicates that regional patients had significantly higher adjusted 30-day and 1-year mortality (in 30-day survivors) than metropolitan patients (Table 3). However, the slightly higher OR for 30-day mortality in remote patients (1.29; 95% CI 0.98-1.69) did not reach significance in the fully adjusted model, and the adjusted HR for one-year mortality (in 30-day survivors) was not higher in remote patients (Table 3).

DISCUSSION

Heart failure is a complex, disabling, and potentially deadly clinical syndrome, of increasing public health importance as the population ages.[21] Our study examined hospitalised patients with 'first-ever' HF, and accordingly, a vast majority (>93%) were emergency presentations to hospital. In this population-based cohort of patients, we found that a sizeable minority of patients (26%) live in rural/remote WA. The majority of the rural patients with HF were from areas of social disadvantage with limited or no access to specialist services for HF, as others have found.[22, 23] Rural area of residence was consistently associated with higher risk-adjusted odds and hazard of short-term mortality at 30 days and 1-year (in 30-day survivors) respectively, compared with metropolitan patients, even after controlling for socio-economic status, Aboriginality, private insurance status and risk factors. The same findings were observed

in the subgroup analyses: both men and women who lived in rural/remote areas of WA; as well as in older patients aged 55 years and over.

Earlier research by Clark et al[24] showed a significantly higher prevalence of congestive HF in rural compared to metropolitan areas among patients aged 60 years and over. Furthermore, rates of echocardiography for diagnosis or specialist referrals and rate of prescribing angiotensin-converting enzyme inhibitor drugs were consistently lower in rural compared with metropolitan areas.[24] Different pharmacotherapy patterns in rural and metropolitan Canadian patients with HF have also been reported.[9] We found that receipt of coronary angiography or interventions were lower in rural patients, consistent with the previous findings,[10, 24] although disparity in discharge medications was not examined in our study.

Western Australia is geographically large, being the size of Western Europe, with much of its area sparsely populated. Accordingly, the tyranny of distance and lack of transport (as the interface between different entry points to the health care system) are major obstacles to accessing appropriate health care for rural West Australians. Access to appropriate specialist expertise also requires transfer between services and there are many reasons why such transfers may not occur. Moreover, there may be limited access to comprehensive primary health care services, poor integration between different levels of care and inadequate services to support ongoing home-based intervention and HF self-management[25] , HF-specific cardiac rehabilitation programs[26] and socio-culturally appropriate services.[27-29] Hence, the dimension of metro-rural divide in the context of Western Australia is larger than that which occurs in other states.[30] Issues of rural and remote health are much more complex than merely the practice of health in another location[3] and are affected by issues such as workforce shortages and retention of healthcare workers, higher out-of-pocket costs and the time and cost of travel.[3]

Rural and remote patients with HF differed considerably from metropolitan patients including being younger, more socially disadvantaged and more likely to be Aboriginal. Despite Australia having universal health insurance through Medicare which allows free access to public hospital treatment and outpatient medical consultations and medications being subsidised, there remain barriers to specialist consultations for socially disadvantaged groups, particularly where upfront cash payments are required. An even more important disparity is the paucity of specialist cardiology care in regional/remote areas. This is evident from the differences in profiles of care between the two sub-populations and the findings that showed rural patients were utilising EDs to fill the gaps in the primary health care and the specialist services in rural areas. Other evidence shows that increasing private health insurance coverage in Australia has been associated with loss of equity after controlling for other factors.[30, 31]

The heterogeneity in the different geographical areas needs to be highlighted. However, our results showed that despite further adjustments for demographics, SEIFA and private health insurance status (both as a proxy for socio-economic status), Aboriginality, emergency presentations, individual comorbidities and interventions, differential difference in mortality outcomes persisted for rural patients compared to metropolitan patients. It is plausible that the type of care received from regional, small district hospitals and/or rural primary care providers compared with metropolitan hospitals and urban general practices has a differential impact on mortality. Around 75% of the rural patients were managed at regional, small district hospitals, while a vast majority of urban patients were treated in tertiary and private hospitals. There might be another reason why fewer people have private insurance in rural areas – because there are only 2 private hospitals in rural areas, and going in as a private patient in a public rural hospital offers little advantage. Hence, rural residents may not see a need for private insurance, and they probably think the likelihood of being admitted to a metro private hospital is low.

In the sensitivity analysis with the three levels for residential location, regional patients showed increased risk-adjusted ORs/HRs of 30-day mortality and 1-year mortality (in 30-day survivors). The association for remote/very remote patients was marginally significant (for 30-day mortality) possibly because of a lack of power. However, previous work by Katzenellenbogen et al[32] found that some older groups living in remote areas had lower MI rates than metropolitan residents, suggesting a possible migration effect of remote patients with heart disease moving to regional/metro centres. The data from the current study may reflect such a phenomenon, with remote HF patients moving to more accessible centres after their incident event and thus benefiting through improved 1-year survival.

Our results are consistent with other studies from Canada and the US which also reported worse outcomes in rural versus metropolitan patients with HF,[8-10] The same rural-metropolitan differential in WA was reported for the incidence of myocardial infarction in Western Australia.[32] However, conflicting evidence was reported from a CVD risk study on South-West Victoria and North-West Adelaide, Australia.[30] That study examined cardiovascular mortality rates without comprehensive adjustment and only a small proportion of the patients examined were Aboriginal.[30] There is also a contextual difference in that HF has high mortality with patients often presenting with heavy comorbidity burden.

The problem of inequalities in health burden and access to health care related to rurality and remoteness is a common theme across many countries including high socioeconomic countries such as Australia and Canada. It is therefore an important issue that is relevant to health policy, health service delivery and health care planning in many countries beyond the local context.

The strengths of this study lie in the quality and near complete ascertainment of the short- and long-term mortality after first HF hospitalization using linked administrative data in Western Australia,[11] and the previous validation with respect to a principal diagnosis of HF.[14] However, socio-deprivation was derived using an area-based measure which gives rise to potential misclassification at an individual level. We have no information as to why people choose not to have private health insurance. Our study also lacked information on use of medications in our cohort. However, in a separate study undertaken by our team[33], the authors found adjusted evidence-based prescription at discharge for patients with acute coronary syndrome was significantly lower in district hospitals versus metropolitan teaching hospitals (OR 0.51, 95% CI 0.32-0.82), as well also in patients with regional versus metropolitan residence (OR 0.55, 95% CI 0.39-0.77). This finding is also likely applicable to the uptake and adherence to evidence-based therapy for HF patients discharged from non-tertiary and rural care hospitals. We have previously shown that the discharge prescription of evidence-based HF medications had a significant impact on subsequent survival[34].

Conclusions

This study highlights the impact of geographical or spatial isolation on mortality outcomes in HF patients as the first step in understanding rural-urban differences. From the health policy perspective, the higher rural mortality likely points to the inequalities in the availability and access to appropriate medical care, rather than compositional differences in rural and metropolitan patients with HF. Rural Western Australia is not homogeneous and the proportion of Aboriginal people increases with remoteness. This has implications for the provision of collaborative models of care for chronic disease management and secondary prevention of HF in rural areas.

Acknowledgements

The authors thank the Western Australian Data Linkage Branch and the staff of the Inpatient Data Collections for the provision of the data and the Registry of Births, Deaths and Marriages for providing the death data.

Competing interests: none declared

Authors contribution: All authors critically reviewed and contributed to the intellectual content of the manuscript. THKT, JMK, MK, SCT and JH were involved with the conception of the study. THKT performed the statistical analyses, supported by MK and drafted the manuscript. SCT, JH and MH provided the clinical expertise. All authors have read and approved the final version of the manuscript.

Extra data is available by emailing Tiew-Hwa Katherine Teng at katherine.teng@uwa.edu.au

Funding

The study had been supported by an NHMRC project grant (#1031057). J Katzenellenbogen is funded by an NHMRC Early Career Fellowship (#037429). The Western Australian Centre for Rural Health receives funding from the Department of Health and Ageing.

Table 1. Baseline characteristics and crude mortality of metropolitan vs rural patients with a 'first-ever' (index) admission for heart failure between 2000 and 2009.

Description	Metropolitan, n (%)	Rural, n (%)	P-value
Cases by ARIA classification[1]			
• Major city	9,006 (69.9)		
• Inner Regional	3,874 (30.1)	1,182 (26.3)	
• Outer Regional		1,807 (40.2)	
• Remote		477 (10.6)	
• Very Remote		1,033 (23.0)	
Total Cases	12,880 (74.1)	4,499 (25.9)	
Women, n (%)	5,511 (42.8)	1,833 (40.7)	0.017
Mean age ±SD (years)	70.8±11.7	67.5±13.4	<0.001
Age groups, n (%)			
• 20-34 years	167 (1.3)	117 (2.6)	<0.001
• 35-49 years	655 (5.1)	382 (8.5)	
• 50-64 years	2,294 (17.8)	1,039 (23.1)	
• 65-84 years	9,764 (75.8)	2,961 (65.8)	
Aboriginal patients, n (%)	241 (1.9)	772 (17.2)	<0.001
Length of stay, mean days ± SD	7.1±8.6	6.4±15.8	0.001
Hospital type			
• Metro tertiary/teaching	7,212 (56.0)	543 (12.1)	<0.001 for all
• Metro/non-teaching	1,282 (10.0)	28 (0.6)	
• Rural regional	48 (0.4)	1,524 (33.9)	
• Rural district/small	58 (0.5)	1,835 (40.8)	
• Private	4,280 (33.2)	569 (12.7)	
Emergency admission, n(%)	12,095 (93.9)	4,265 (94.8)	0.028
Private health insurance, n(%)	4,197 (32.6)	915 (20.3)	<0.001
SEIFA (socio-economic status), n(%)			
• 1st quintile (most disadvantaged)	3 (0.2)	1,182 (26.5)	<0.001 for all
• 2nd quintile	1,693 (13.2)	1,085 (24.3)	
• 3rd quintile	4,827 (37.4)	1,476 (33.1)	
• 4th quintile	2,918 (22.6)	631 (14.1)	
• 5th quintile (least disadvantaged)	3,439 (26.6)	89 (2.0)	
Source of referral – Professional, n (%)			
• General practitioner	628 (4.9)	838 (18.4)	<0.001
• Specialist clinician	3,235 (25.2)	688 (15.1)	

• Outpatient Department clinician	534 (4.1)	137 (3.0)	
• Emergency Department clinician	7,650 (59.6)	2,527 (55.6)	
• Hospital clinician	89 (0.7)	67 (1.5)	
• Community health clinician	16 (0.1)	36 (0.8)	
• Others	106 (0.8)	33 (0.7)	
• Missing	572 (4.5)	221 (4.9)	
Mode of transport to hospital, n (%)			
• Private/public transport	6,193 (48.3)	2,952 (64.9)	<0.001
• Ambulance –patient transport only	542 (4.2)	88 (1.9)	
• Ambulance -emergency	4,938 (38.5)	884 (19.4)	
• Royal Flying Doctor Service	16 (0.1)	130 (2.9)	
• Other	115 (0.9)	156 (3.4)	
• Missing	1,026 (8.0)	337 (7.4)	
Comorbidities, n (%) *			
All ischaemic heart disease †	6,426 (49.9)	1,895 (42.1)	0.001
Acute myocardial infarction	2,242 (17.4)	636 (14.1)	<0.001
Unstable angina	1,987 (15.4)	485 (10.8)	<0.001
Hypertension	7,194 (55.9)	2,408 (53.5)	0.007
Atrial fibrillation	5,579 (43.3)	1,692 (37.6)	<0.001
Diabetes	4,104 (31.9)	1,543 (34.3)	0.003
Chronic kidney disease	2,851 (22.1)	918 (20.4)	0.015
Renal failure	415 (3.2)	181 (4.0)	0.012
COPD	2,600 (20.2)	1,146 (25.5)	<0.001
Cerebrovascular disease	1,404 (10.9)	391 (8.7)	<0.001
Rheumatic heart disease/rheumatic valvular heart disease	1,868 (14.5)	526 (11.7)	<0.001
Valvular heart disease, non-rheumatic	2,663 (20.7)	703 (15.6)	<0.001
Interventions, n (%)			
History of PCI	779 (6.1)	203 (4.5)	<0.001
History of CABG	342 (2.7)	118 (2.6)	0.891
Index PCI	228 (1.8)	36 (0.8)	<0.001
Index CABG	374 (2.9)	86 (1.9)	<0.001
Coronary angiography	6,003 (46.6)	1,711 (38.0)	<0.001
Charlson Index n (%)			
0	73 (0.6)	32 (0.7)	
1-2	5,780 (44.9)	2,158 (48.0)	0.001 for all
3-4	3,474 (27.0)	1,164 (25.9)	
>4	3,553 (27.6)	1,145 (25.4)	
Crude cumulative mortality			
30-day case fatality**	838 (6.6)	306 (6.9)	0.474
1-year mortality***	2,364 (20.5)	829 (20.7)	0.799
Mean presentations to ED within 1-year follow-up, n ±SD	2.8±3.1	4.9±5.7	<0.001

Continuous variables expressed as mean ± SD. Categorical variables expressed as proportions, n (%).
P-value is for difference between Metro and rural patients
* Patients could have multiple comorbidities.
† All ischaemic heart disease includes acute myocardial infarction.
PCI – percutaneous coronary intervention
CABG – coronary artery bypass graft
** Patients admitted in December 2009 were excluded from analysis
*** Year 2009 was used as a follow-up period.

Table 2. Step-wise risk adjustment for 30-day mortality and 1-year mortality (in 30-day survivors) in rural patients with index heart failure vs metropolitan patients.

Risk adjustment	Odds ratio [(OR), 95% CI]	p-value
Death at 30 days from index admission		
Unadjusted	1.05 (0.92-1.20)	0.487
Rural patients adjusted for:		
1. Age	1.16 (1.01-1.33)	0.035
2. Model 2 (socio-demographics): Age, sex, period, Aboriginality, SEIFA*, private insurance status	1.18 (1.01-1.38)	0.047
3. Model 2 + emergency presentation, Charlson index	1.26 (1.07-1.49)	0.005
4. Model 3 + individual comorbidities**, interactions, insurance status, emergency presentation	1.26 (1.07-1.48)	0.007
5. Model 4 + PCI/CABG***	1.25 (1.06-1.48)	0.007
Death at 1-year in 30-day survivors	**Hazard ratio [(HR), 95% CI]**	**p-value**
Unadjusted	0.99 (0.90-1.09)	0.866
Rural patients adjusted for		
1. Age	1.11 (1.01-1.23)	0.030
2. Model 2- Age, sex, period, Aboriginality, SEIFA*, private insurance	1.06 (0.95-1.20)	0.291
3. Model 2 + emergency presentation, Charlson index	1.14 (1.02-1.28)	0.027
4. Model 3 + individual comorbidities**, interactions	1.14 (1.02-1.28)	0.032
5. Model 4 + PCI/CABG***	1.13 (1.02-1.27)	0.040

*SEIFA – Socio-Economic Index for Areas
** Individual comorbidities adjusted in the models include: hypertension, atrial fibrillation, rheumatic heart disease, diabetes, chronic kidney disease, renal failure, unstable angina, acute myocardial infarction, other ischaemic heart disease, cerebrovascular disease, chronic obstructive pulmonary disease.
*** PCI/CABG – percutaneous coronary intervention/coronary artery bypass graft

Table 3. Sensitivity analysis showing step-wise risk adjustment for 30-day mortality and 1-year mortality (in 30-day survivors) in patients with index heart failure by level of residential location

Risk-adjustment	Regional WA		Remote/very remote WA	
Death at 30-day from index admission†	**Odds ratio (95% CI)**	**p-value**	**Odds ratio (95% CI)**	**p-value**
• Unadjusted	1.10 (0.94-1.29)	0.227	0.95 (0.76-1.19)	0.649
Adjusted for:				
1. Age	1.08 (0.99-1.17)	0.068	1.20 (1.07-1.36)	0.002
2. Age, sex, period, Aboriginality, SEIFA, private insurance	1.17 (0.98-1.38)	0.083	1.21 (0.93-1.59)	0.153
3. Model 2 + emergency presentation, Charlson index	1.24 (1.04-1.48)	0.015	1.34 (1.02-1.75)	0.033
4. Model 3 + individual comorbidities, interactions	1.25 (1.04-1.49)	0.014	1.28 (0.98-1.68)	0.069
5. Model 4 + PCI/CABG	1.24 (1.04-1.48)	0.016	1.29 (0.98-1.69)	0.071
Death at 1-year in 30-day survivors†				
• Unadjusted	1.09 (0.97-1.21)	0.136	0.81 (0.68-0.95)	0.011
Adjusted for:				
1. Age	1.13 (1.01-1.26)	0.030	1.07 (0.91-1.27)	0.419
2. Age, sex, period, Aboriginality, SEIFA, private insurance	1.10 (0.97-1.24)	0.139	0.93 (0.76-1.14)	0.477
3. Model 2 + emergency presentation, Charlson index	1.17 (1.03-1.32)	0.013	1.04 (0.86-1.27)	0.670
4. Model 3 + individual comorbidities, interactions	1.18 (1.04-1.33)	0.010	1.02 (0.84-1.24)	0.878
5. Model 4 + PCI/CABG	1.17 (1.03-1.32)	0.014	1.02 (0.84-1.24)	0.870

† Patients with metropolitan residence as the reference group.

REFERENCES

1. Australian Institute of Health and Welfare. Rural, regional and remote health - Indicators of health. Canberra, AIHW, 2005. Cat. No. PHE 59.

2. AIHW 2010. Cardiovascular medicines and primary health care: a regional analysis. Canberra: AIHW, 2010.

3. Wakerman J, Humphreys JS. Rural health: why it matters. *Med J Aust*. 2002;**176**:457-8.

4. Dixon J, Welch N. Researching the rural-metropolitan health differential using the 'social determinants of health'. *Aust J Rural Health*. 2000;**8**:254-60.

5. Australian Bureau of Statistics. Population distribution, Aboriginal and Torres Strait Islander Australians, 2006. ABS, 2007 Cat. no. 3238.0.55.001.

6. Humphreys J, Hegney D, Lipscombe J, et al. Whither rural health? Reviewing a decade of progress in rural health. *Aust J Rural Health*. 2002;**10**:2-14.

7. Levy D, Kenchaiah S, Larson MG et al. Long-term trends in the incidence of and survival with heart failure. *N Engl J Med*. 2002;**347**:1397-402.

8. Muus KJ, Knudson A, Klug MG et al. Effect of post-discharge follow-up care on re-admissions among US veterans with congestive heart failure: a rural-urban comparison. *Rural Remote Health*. 2010;**10**:1447.

9. Gamble JM, Eurich DT, Ezekowitz JA, et al. Patterns of care and outcomes differ for urban versus rural patients with newly diagnosed heart failure, even in a universal healthcare system. *Circ Heart Fail*. 2011;**4**:317-23.

10. Jin Y, Quan H, Cujec B, et al. Rural and urban outcomes after hospitalization for congestive heart failure in Alberta, Canada. *J Card Fail*. 2003;**9**:278-85.

11. Holman CD, Bass AJ, Rosman DL, et al. A decade of data linkage in Western Australia: strategic design, applications and benefits of the WA data linkage system. *Aust Health Rev*. 2008;**32**:766-77.

12. Teng TH, Finn J, Hobbs M et al. Heart failure: incidence, case fatality, and hospitalization rates in Western Australia between 1990 and 2005. *Circ Heart Fail*. 2010;**3**:236-43.

13. Teng TH, Katzenellenbogen JM, Thompson SC et al. Incidence of first heart failure hospitalization and outcomes in Aboriginal and non-Aboriginal patients in Western Australia, 2000-2009. (In-press). 2013.

14. Teng T-H, Finn J, Hung J et al. A Validation Study: How Effective is The Hospital Morbidity Data as a Surveillance Tool for Heart Failure in Western Australia? *Aus NZ J Public Health*. 2008;**32**:405-7.

15. Australian Institute of Health and Welfare. Rural, regional and remote health: a guide to remoteness classification. Canberra, ACT: 2004. Cat no. PHE 53.

16. Geographic Information Systems EB, Public Health Division. Department of Health Health Geographical Classification, Version 4.0. I Perth: Department of Health, WA; 2013.

17. Australian Bureau of Statistics. Information paper: census of population and housing - socio-economic indexes for areas, Australia. Canberra: ABS, 2003. Cat no. 2033.055.001.

18. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;**40**:373-83.

19. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *J Clin Epidemiol*. 1993;**46**:1075-9.

20. Krumholz HM, Wang Y, Mattera JA et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with heart failure. *Circulation*. 2006;**113**:1693-701.

21. Krum H, Jelinek MV, Stewart S, et al. Guidelines for the prevention, detection and management of people with chronic heart failure in Australia 2006. *Med J Aust*. 2006;**185**:549-57.

22. Wakerman J, Humphreys JS, Wells RW, et al. Improving rural and remote health. *Med J Aust.* 2007;**186**:486.

23. Unger CC, Warren N, Canway R, et al. Type 2 diabetes, cardiovascular disease and the utilisation of primary care in urban and regional settings. *Rural Remote Health*. 2011;**11**:1795.

24. Clark RA, Eckert KA, Stewart S, et al. Rural and urban differentials in primary care management of chronic heart failure: new data from the CASE study. *Med J Aust*. 2007;**186**:441-5.

25. Stewart S, Pearson S, Horowitz JD. Effects of a home-based intervention among patients with congestive heart failure discharged from acute hospital care. *Arch Intern Med*. 1998;**158**:1067-72.

26. Davidson PM, Cockburn J, Newton PJ, et al. Can a heart failure-specific cardiac rehabilitation program decrease hospitalizations and improve outcomes in high-risk patients? *Eur J Cardiovasc Prev Rehabil*. 2010;**17**:393-402.

27. Digiacomo M, Davidson PM, Taylor KP, et al. Health information system linkage and coordination are critical for increasing access to secondary prevention in Aboriginal health: a qualitative study. *Quality in Primary Care*. 2010;**18**:17-26.

28. DiGiacomo ML, Thompson SC, Smith JS, et al. 'I don't know why they don't come': barriers to participation in cardiac rehabilitation. *Aust Health Rev*. 2010;**34**:452-7.

29. Thompson SC, Digiacomo ML, Smith JS, et al. Are the processes recommended by the NHMRC for improving Cardiac Rehabilitation (CR) for Aboriginal and Torres Strait Islander people being implemented?: an assessment of CR Services across Western Australia. *Australia and New Zealand Health Policy*. 2009;**6**:29.

30. Tideman P, Taylor AW, Janus E, et al. A comparison of Australian rural and metropolitan cardiovascular risk and mortality: the Greater Green Triangle and North West Adelaide population surveys. *BMJ open*. 2013;**3**:e003203.

31. Hindle D, McAuley I. The effects of increased private health insurance: a review of the evidence. *Aust Health Rev*. 2004;**28**:119-38.

32. Katzenellenbogen JM, Sanfilippo FM, Hobbs MS et al. Complex impact of remoteness on the incidence of myocardial infarction in Aboriginal and non-Aboriginal people in Western Australia. *Aust J Rural Health*. 2012;**20**:305-11.

33. Gausia K, Katzenellenbogen JM, Sanfilippo FM et al. Evidence-based prescribing of drugs for secondary prevention of acute coronary syndrome in Aboriginal and non-Aboriginal patients admitted to Western Australian hospitals. *Internal Medicine Journal*. 2014; in-press.

34 Teng T-H, Hung J, Finn J. The effect of evidence-based medication use on long-term survival in patients hospitalized for heart failure in Western Australia. *Med J Aust*. 2010;**192**:306-10.

Heart failure outcomes are worse for patients from rural areas in Western Australia

Authors: Tiew-Hwa Katherine Teng[1], Judith M Katzenellenbogen[1], Joseph Hung[2], Matthew Knuiman[3], Frank M Sanfilippo[3], Elizabeth Geelhoed[3], Michael Hobbs,[3] Sandra C Thompson[1]

Affiliations:

1. Western Australian~~Combined Universities~~ Centre for Rural Health, University of Western Australia, Perth, WA, Australia.
2. Sir Charles Gairdner Hospital Unit, School of Medicine & Pharmacology, University of Western Australia, Perth, WA, Australia.
3. School of Population Health, University of Western Australia, Perth, WA, Australia.

Corresponding author:

Tiew-Hwa Katherine Teng (Dr)

Western Australian~~Combined Universities~~ Centre for Rural Health, School of Primary, Aboriginal and Rural Health -the University of Western Australia, 35 Stirling Highway (M706), Crawley, WA 6009, Australia.

Email: katherine.teng@uwa.edu.au

Office Phone: +61 (8) 9346 2755

Office Fax: +61 (8) 9346 1665

Key words: heart failure, mortality, rural health, epidemiology

Word count: 3,265~~2 818~~

Abstract

~~**Background**: Remoteness and variable access to health care can cause important disparities in outcomes following heart failure (HF) for metropolitan versus rural populations.~~

Objectives: We examined differentials in short-term (30-day mortality) and 1-year mortality (in 30-day survivors) following index (first-ever) hospitalisation for heart failure (HF), between rural and metropolitan patients resident in Western Australia (WA).

Design: A population-based cohort study.

Setting: Hospitalised patients in WA, Australia.

Participants: Index patients aged 20-84 years with a first-ever hospitalisation for HF between 2000 and 2009 (with no prior admissions for HF in previous ten years), identified using the WA linked-health data.

Main outcome measures: 30-day and 1-year all-cause mortality (in 30-day survivors) following index admission for HF.

Results: Of 17,379 index HF patients identified, 25.9% (4,499) were from rural areas. Rural patients were significantly younger at first HF hospitalisation than metropolitan patients. Aboriginal patients comprised 1.9% of metropolitan and 17.2% of rural patients. Despite some statistical differences, the prevalence of antecedents including ischaemic heart disease, hypertension, diabetes, and chronic kidney disease was high (>20%) in both subpopulations. After adjusting for age only, patients from rural areas had a higher risk of 30-day death [OR 1.16 (95% CI 1.01-1.33)] and 1-year death in 30-day survivors [HR 1.11 (95% CI 1.01-1.23)]. ~~The age, sex and calendar-year adjusted OR for 30-day mortality comparing rural to metropolitan patients was 1.16 (95% CI 1.01 – 1.33) and the HR for 1-year mortality was 1.11 (1.01 – 1.22).~~ These relative risk estimates increased and remained significant after further progressive adjustments for Aboriginality, socio-economic status, insurance status, emergency presentation, individual comorbidities and revascularization with OR 1.25 (1.06 – 1.48) for 30-day mortality

and HR 1.13 (1.02– 1.27) for one-year mortality. The addition of the weighted Charlson index to the 30-day model improved the 'c' statistic (under the ROC curve) from 0.656 (using a variation of administrative claims model) to 0.714.

Conclusions: Remoteness and variable access to health care can cause important disparities in health outcomes. Rural patients with HF in WA have poorer risk-adjusted outcomes compared to metropolitan patients. This finding has important implications for chronic disease management and provision of health services in rural Australia.

Article summary

Strengths and limitations of this study

- The strengths of this study lie in the quality and near complete ascertainment of the short and long-term mortality after first HF hospitalization using the Western Australia (WA) linked administrative data.
- A principal diagnosis of HF in the WA linked hospital morbidity data had been previously validated against the Boston diagnostic criteria with a positive predictive value of 92.4% for 'definite' HF.
- We found a higher risk-adjusted 30-day and 1-year mortality (in 30-day survivors) in rural (compared with metropolitan) patients following first HF hospitalisation in Western Australia between 2000 and 2009. The mortality disparity between rural and metropolitan patients persisted after adjustment for Aboriginality, other major socio-demographic differences and comorbidities.
- However, we do not have information to adjust for medications in our cohort and socio-deprivation was derived using an area-based measure which could give rise to potential misclassification.
- The findings have implications for enhancing chronic disease management and secondary prevention of HF in rural Western Australia.

Introduction

The management of chronic diseases is an increasing public health concern in rural areas.[1] Australians living in regional and remote areas generally have poorer health than metropolitan residents,[1] with higher rates of chronic diseases reported in these areas.[2] The health needs of many regional and remote communities have not been met,[3] despite many initiatives to address geographical inequalities over the last decade. Generally, rural populations experience poorer access to and limited availability of health and allied health care services with the provision of health care services inversely proportional to the distance from capital cities.[1]

Rural inhabitants have a constellation of risk factors and experience greater socio-economic disadvantage[4] which also affect people's need for and access to health services.[2] Any understanding of the rural dimension in health needs to be inclusive of Indigenous Australians as Aboriginal and Torres Strait Islander peoples are more likely to live in non-metropolitan areas.[5] Additionally, cardiovascular disease (CVD), including heart failure (HF), is a major cause of premature death in the Indigenous population in Australia.[6]

Heart failure is a chronic debilitating disease, with 50%-60% mortality within 5 years.[7] HF is a major cause of death from CVD and outcomes can be adversely affected by restricted access to hospital and continuing care as well as the standard of clinical management.[8] Therefore death rates from HF are a useful indicator of disparities in health access and care between rural and metropolitan patients. Previous studies from Canada [9, 10] suggest important disparities in the outcomes of HF among metropolitan versus rural populations. Although Canada has similarities in the universal health care system and geography as Australia, there are no previous studies (on HF) in the Australian context.

We examined differentials in ~~short term (~~30-day mortality~~)~~ and 1-year mortality (in 30-day survivors) following index (first-ever) hospitalisation for HF, between rural and metropolitan patients resident in Western Australia.

Methodology

Study setting and data sources

The study was performed in Western Australia, which is geographically the largest ~~(by land mass)~~ of six states in Australia, with a land mass spanning 2.53 million km^2. Based on the 2006 census, about 27% of the 2.5 million inhabitants in Western Australia lived in what is referred as regional and remote Australia. Western Australia is also home to the third largest number of Aboriginal Australians (13.2% of total Aboriginal population). Australia has a universal health care system with free public acute hospital services, while allowing choice through a mix of public and private health care service providers.

Data were obtained from the Western Australian Data Linkage System, a population-based electronic linked health database which has been used extensively for health-related research[11]. The Hospital Morbidity Data Collection (HMDC), a core dataset of the data linkage system, records information on hospital admissions throughout Western Australia (WA), and is regularly audited for quality and accuracy. HMDC data are routinely linked to the Mortality register using probabilistic matching with greater than 99% accuracy.[11]

The Emergency Department data Collection (EDDC) containing data on emergency department (ED) activity in Western Australia's public and private hospitals (under contract with the WA Government) was used to examine re-presentations to ED within 1-year of follow-up from index admission of HF.

Ours ~~study~~ was a population-based cohort study using linked health data comprising all WA residents aged 20-84 years who were admitted with a first hospitalisation for HF between 2000 and 2009, [with no previous admissions in the past ten years] as described previously.[12, 13] Inclusion in the study was based on a principal discharge diagnosis of HF or a secondary discharge diagnosis of HF with a principal discharge diagnosis of a cardiovascular condition, excluding acute myocardial infarction (AMI). The coding for HF as a principal discharge diagnosis in the HMDC has been previously validated against the Boston diagnostic criteria with a positive predictive value of 92.4% for 'definite' HF.[14]

Ethics approvals were obtained from the WA Aboriginal Health Ethics Committee and Human Research Ethics Committees of the Department of Health Western Australia and The University of Western Australia.

Geographical classification

Using residential post codes, the Accessibility/Remoteness Index of Australia (ARIA) classification was used to define the five categories of residence based on road distance to service centres: major cities, inner regional, outer regional, remote and very remote.[15] For the regression analysis, place of residence was dichotomised into metropolitan residence (based on the greater Perth metropolitan city definition,[16] including urban and some of inner regional), and rural residence (remainder of inner regional, outer regional, remote and very remote). A sensitivity analysis was performed using three geographical locations: (i) metropolitan[16]; (ii) regional (remainder of inner regional and all of outer regional); and (iii) remote/very remote.

Socio-Economic Indices for Areas (SEIFA)[17]–, were assigned to each patient based on residential postcodes and divided into quintiles, based on pre-defined cut-points. The first quintile (Q1) represents the most disadvantaged group and fifth quintile (Q5) the least.

Comorbidities, interventions and procedures

Individual comorbidities within 5 years or concurrent with index HF hospitalization were identified: hypertension, atrial fibrillation, rheumatic fever and rheumatic heart disease, diabetes, valvular heart disease, chronic kidney disease, renal failure, chronic obstructive pulmonary disease (COPD), unstable angina, AMI, other ischaemic heart disease (IHD), and cerebrovascular disease. A Charlson comorbidity score [18] was calculated for each index case by applying a fixed 5-year look-back period using the HMDC. We used the Dartmouth-Manitoba ICD code assignments [19] in calculating the Charlson score based on the original 17 Charlson comorbidities. Percutaneous coronary intervention or coronary artery bypass grafting (CABG) and coronary angiography were similarly identified.

Statistical analysis

Descriptive analyses were used to characterise differences in the socio-demographics, comorbidities, and interventions/procedures received between HF patients who reside in metropolitan compared to rural areas. Means and standard deviations were calculated for continuous variables whilst frequencies and proportions were derived for categorical data. The Pearson chi-squared test was used to test for differences in categorical variables and the t-test or Mann-Whitney test for continuous variables. Multivariable logistic regression was used to determine predictors of death within 30 days, with odds ratios (ORs) and their 95% CIs reported. Multivariable Cox regression was used to determine survival to 1 year in 30-day survivors and hazard ratios (HRs) and their 95% CIs reported. All patients admitted between 1 January 2000 and 30 November 2009 were included for 30-day survival analysis. For survival analysis to 1 year (from index admission), only patients admitted with their first HF between 2000 and 2008 were included.

Adjustment for cluster correlation with postcode as the cluster was examined and found to have a non-significant effect and hence not included in the final models.

Results

Table 1 shows the geographic and socio-demographic characteristics of patients with first HF hospitalisation living in metropolitan (n=12,880, 74.1%) and rural areas (n=4,499, 25.9%) between 2000 and 2009. A total of 33.6% of rural patients were from remote or very remote areas and the remainder from regional areas. Rural compared with metropolitan patients were significantly younger at first HF hospitalisation (mean age: 68±13 vs 71±12 years, p<0.001), and more likely men (59.3 vs 57.2%, p=0.017). Aboriginal (including Torres Strait Islander) patients comprised 17.2% of rural cases vs 1.9% of metropolitan cases. About 75% of rural HF patients were seen at public ~~rural~~ regional or small district hospitals compared with less than 1% of metropolitan patients. Rural patients were less likely to have private health insurance compared to metropolitan patients (20.3% vs 32.6%, p<0.001). More than 50% of rural patients (versus~~s~~ 13.4% metropolitan patients) were in the two lowest quintiles (index of most disadvantage) of SEIFA, a proxy for socio-economic status.

Profile of care prior to the index hospitalisation for HF and pre-hospital emergency medical service (EMS) coverage by ambulance was different in both sub-populations (Table 1). Metropolitan (versus rural) patients were more likely to be managed by specialist clinicians (25.2% vs 15.1% rural); by contrast, more rural patients were cared for by GPs (18.4% versus 4.9% metropolitan). Metropolitan (versus rural) patients were more likely to be transported by EMS ambulance to admitting hospitals (38.5% versus 19.4%). About 65% of rural patients depended on private/public transport to get to admitting hospitals. Notably, rural (versus metropolitan) patients were also more likely (49.1% versus 20.4%) to present to EDs (for any condition) with tri-age scores of 4 or 5 (for semi-urgent or non-urgent cases) during the 1-year

follow-up, suggesting EDs being used to fill the gaps in primary care or specialist services in rural areas.

A higher proportion of rural patients had a Charlson index of 1-2 although a small but significantly larger proportion of metropolitan patients (being older) scored >3 (Table 1). Despite some statistical differences between metropolitan and rural patients, there was a high prevalence of potential antecedent HF risk factors including ischaemic heart disease, hypertension, atrial fibrillation, diabetes, chronic kidney disease, COPD, cerebrovascular disease and rheumatic and non-rheumatic valvular heart disease in both subpopulations (see Table 1). Rates of coronary interventions (prior to or on index admissions) were low overall but significantly lower in rural patients. When adjusted for age, sex, period, Aboriginality and Charlson comorbidity index, rural patients with HF were less likely to have coronary angiography compared to metropolitan patients (risk-adjusted odds (OR)=0.81; 95% CI 0.77-0.86, p<0.001).

Crude 30-day and 1-year cumulative all-cause mortality and unadjusted risk were not significantly different between metropolitan and rural patients with first HF hospitalisation (Table 1, Table 2). After age adjustmenting only, patients from rural areas had a higher risk of 30-day death [OR 1.16 (95% CI 1.01-1.33)] and 1-year death in 30-day survivors [HR 1.11 (95% CI 1.01-1.23), see Table 2]. for age, sex and period, patients from rural areas had a higher risk of 30 day death (OR 1.16, 95% CI 1.01 1.33) and 1 year death in 30 day survivors (HR 1.11, 95% CI 1.01 1.22) (see Table 2). The difference in survival between rural and metropolitan patients increased with further adjustment for socio-demographic differences including Aboriginality, SEIFA (as proxy for socio-economic status), private insurance status, emergency presentation, and the Charlson comorbidity index, with OR of 1.26 and HR of 1.14. The association between rurality and mortality persisted between the two subpopulations after further adjustment to

include other individual comorbidities of interest, significant interaction effects and interventions (see Table 2). The addition of the weighted Charlson index to the 30-day model (using a variation of the administrative claims model[20] improved the 'c' statistic (under the ROC curve) from 0.656 to 0.714.

No significant interactions were found between sex and rurality; Aboriginality and rurality (as location of residence). Further evaluation of mortality in men and women separately and in younger (<55 years) and older patients showed similar odds/hazards of death at 30 days and 1-year (in 30-day survivors) in rural patients compared with metropolitan patients.

A sensitivity analysis using three levels of geographical residence (metropolitan, regional and remote), indicates that regional patients had significantly higher adjusted 30-day and 1-year mortality (in 30-day survivors) than metropolitan patients (Table 3). However, the slightly higher OR for 30-day mortality in remote patients (1.29; 95% CI 0.98-1.69) did not reach significance in the fully adjusted model, and the adjusted HR for one-year mortality (in 30-day survivors) was not higher in remote patients (Table 3).

DISCUSSION

Heart failure is a complex, disabling, and potentially deadly clinical syndrome, of increasing public health importance as the population ages.[21] Our study examined hospitalised patients with 'first-ever' HF, and accordingly, a vast majority (>93%) were emergency presentations to hospital. In this population-based cohort of patients, we found that a sizeable minority of patients (26%) live in rural/remote WA. The majority of the rural patients with HF were from areas of social disadvantage with limited or no access to specialist services for HF, as others have found.[22, 23] Rural area of residence was consistently associated with higher risk-adjusted odds and hazard of short-term mortality at 30 days and 1-year (in 30-day survivors)

respectively, compared with metropolitan patients, even after controlling for socio-economic status, Aboriginality, private insurance status and risk factors. The same findings were observed in the subgroup analyses: both men and women who lived in rural/remote areas of WA; as well as in older patients aged 55 years and over.

Earlier research by Clark et al[24] showed a significantly higher prevalence of congestive HF in rural compared to metropolitan areas among patients aged 60 years and over. Furthermore, rates of echocardiography for diagnosis or specialist referrals and rate of prescribing angiotensin-converting enzyme inhibitor drugs were consistently lower in rural compared with metropolitan areas.[24] Different pharmacotherapy patterns in rural and metropolitan Canadian patients with HF have also been reported.[9] We found that receipt~~uptake~~ of coronary angiography or interventions were lower in rural patients, consistent with the previous findings,[10, 24] although disparity in discharge medications was not examined in our study.

Western Australia is geographically large, being the size of Western Europe, with much of its area sparsely populated. Accordingly, the tyranny of distance and lack of transport (as the interface between different entry points to the health care system) are major obstacles to accessing appropriate health care for rural West Australians. Access to appropriate specialist expertise also requires transfer between services and there are many reasons why such transfers may not occur. Moreover, there may be limited access to comprehensive primary health care services, poor integration between different levels of care and inadequate services to support ongoing home-based intervention and HF self-management[25] , HF-specific cardiac rehabilitation programs[26] and socio-culturally appropriate services.[27-29] Hence, the dimension of metro-rural divide in the context of Western Australia is larger than that which occurs in other states.[30] Issues of rural and remote health are much more complex than merely the practice of health in another location[3] and are affected by issues such as workforce

shortages and retention of healthcare workers, higher out-of-pocket costs and the time and cost of travel.[3]

Rural and remote patients with HF differed considerably from metropolitan patients including being younger, more socially disadvantaged and more likely to be Aboriginal. Despite Australia having universal health insurance through Medicare which allows free access to public hospital treatment and outpatient medical consultations and medications being subsidised, there remain barriers to specialist consultations for socially disadvantaged groups, particularly where upfront cash payments are required. An even more important disparity is the paucity of specialist cardiology care in regional/remote areas. This is evident from the differences in profiles of care between the two sub-populations and the findings that showed rural patients were utilising EDs to fill the gaps in the primary health care and the specialist services in rural areas. Other eEvidence shows that increasing private health insurance coverage in Australia has been associated with loss of equity after controlling for other factors.[30, 31]

The heterogeneity in the different geographical areas needs to be highlighted. However, oOur results showed that despite further adjustments for demographics, SEIFA and private health insurance status (both as a proxy for socio-economic status), Aboriginality, emergency presentations, individual comorbidities and interventions, differential difference in mortality outcomes persisted for rural patients compared to metropolitan patients. It is plausible that the type of care received from regional, small district hospitals and/or rural primary care providers compared with metropolitan hospitals and urban general practices has a differential impact on mortality. Around 75% of the rural patients were managed at regional, small district hospitals, while a vast majority of urban patients were treated in tertiary and private hospitals. There might be another reason why fewer people have private insurance in rural areas – because there are only 2 private hospitals in rural areas, and going in as a private patient in a public rural hospital

offers little advantage. Hence, rural residents may not see a need for private insurance, and they probably think the likelihood of being admitted to a metro private hospital is low.

In the sensitivity analysis with the three levels for residential location, regional patients showed increased risk-adjusted ORs/HRs of 30-day mortality and 1-year mortality (in 30-day survivors). The association for remote/very remote patients was marginally significant (for 30-day mortality) possibly because of a lack of power. However, previous work by Katzenellenbogen et al[32] found that some older groups living in remote areas had lower MI rates than metropolitan residents, suggesting a possible migration effect of remote patients with heart disease moving to regional/metro centres. The data from the current study may reflect such a phenomenon, with remote HF patients moving to more accessible centres after their incident event and thus benefiting through improved 1-year survival.

Our results are consistent with other studies from Canada and the US which also reported worse outcomes in rural versus metropolitan patients with HF,[8-10] The same rural-metropolitan differential in WA was reported for the incidence of myocardial infarction in Western Australia.[32] However, conflicting evidence was reported from a CVD risk study on South-West Victoria and North-West Adelaide, Australia.[30] That study examined cardiovascular mortality rates without comprehensive adjustment and only a small proportion of the patients examined were Aboriginal.[30] There is also a contextual difference in that HF has high mortality with patients often presenting with heavy comorbidity burden.

The problem of inequalities in health burden and access to health care related to rurality and remoteness is a common theme across many countries including high socioeconomic countries such as Australia and Canada. It is therefore an important issue that is relevant to health policy, health service delivery and health care planning in many countries beyond the local context.

The strengths of this study lie in the quality and near complete ascertainment of the short- and long-term mortality after first HF hospitalization using linked administrative data in Western Australia,[11] and the previous validation with respect to a principal diagnosis of HF.[14] However, socio-deprivation was derived using an area-based measure which gives rise to potential misclassification at an individual level. We have no information as to why people choose not to have private health insurance. Our study also lacked information on use of medications in our cohort. However, in a separate study undertaken by our team[33], the authors found adjusted evidence-based prescription at discharge for patients with acute coronary syndrome was significantly lower in district hospitals versus metropolitan teaching hospitals (OR 0.51, 95% CI 0.32-0.82), as well also in patients with regional versus metropolitan residence (OR 0.55, 95% CI 0.39-0.77). This finding is also likely applicable to the uptake and adherence to evidence-based therapy for HF patients discharged from non-tertiary and rural care hospitals. We have previously shown that the discharge prescription of evidence-based HF medications had a significant impact on subsequent survival[34].

Conclusions

This study highlights the impact of geographical or spatial isolation on mortality outcomes in HF patients as the first step in understanding rural-urban differences. From the health policy perspective, the higher rural mortality likely points to the inequalities in the availability and access to appropriate medical care, rather than compositional differences in rural and metropolitan patients with HF. Rural Western Australia is not homogeneous and the proportion of Aboriginal people increases with remoteness. This has implications for the provision of collaborative models of care for chronic disease management and secondary prevention of HF in rural areas.

Acknowledgements

The authors thank the Western Australian Data Linkage Branch and the staff of the Inpatient Data Collections for the provision of the data and the Registry of Births, Deaths and Marriages for providing the death data.

Competing interests: none declared

Authors contribution: All authors critically reviewed and contributed to the intellectual content of the manuscript. THKT, JMK, MK, SCT and JH were involved with the conception of the study. THKT performed the statistical analyses, supported by MK and drafted the manuscript. SCT, JH and MH provided the clinical expertise. All authors have read and approved the final version of the manuscript.

Extra data is available by emailing Tiew-Hwa Katherine Teng at katherine.teng@uwa.edu.au

Funding

The study had been supported by an NHMRC project grant (#1031057). J Katzenellenbogen is funded by an NHMRC Early Career Fellowship (#037429). The Western Australian~~Combined Universities~~ Centre for Rural Health receives funding from the Department of Health and Ageing.

Table 1. Baseline characteristics and crude mortality of metropolitan vs rural patients with a 'first-ever' (index) admission for heart failure between 2000 and 2009.

Description	Metropolitan, n (%)	Rural, n (%)	P-value
Cases by ARIA classification[1]			
• Major city	9,006 (69.9)		
• Inner Regional	3,874 (30.1)	1,182 (26.3)	
• Outer Regional		1,807 (40.2)	
• Remote		477 (10.6)	
• Very Remote		1,033 (23.0)	
Total Cases	12,880 (74.1)	4,499 (25.9)	
Women, n (%)	5,511 (42.8)	1,833 (40.7)	0.017
Mean age ±SD (years)	70.8±11.7	67.5±13.4	<0.001
Age groups, n (%)			
• 20-34 years	167 (1.3)	117 (2.6)	<0.001
• 35-49 years	655 (5.1)	382 (8.5)	
• 50-64 years	2,294 (17.8)	1,039 (23.1)	
• 65-84 years	9,764 (75.8)	2,961 (65.8)	
Aboriginal patients, n (%)	241 (1.9)	772 (17.2)	<0.001
Length of stay, mean days ± SD	7.1±8.6	6.4±15.8	0.001
Hospital type			
• Metro tertiary/teaching	7,212 (56.0)	543 (12.1)	<0.001 for all
• Metro/non-teaching	1,282 (10.0)	28 (0.6)	
• Rural regional	48 (0.4)	1,524 (33.9)	
• Rural district/small	58 (0.5)	1,835 (40.8)	
• Private	4,280 (33.2)	569 (12.7)	
Emergency admission, n(%)	12,095 (93.9)	4,265 (94.8)	0.028
Private health insurance, n(%)	4,197 (32.6)	915 (20.3)	<0.001
SEIFA (socio-economic status), n(%)			
• 1st quintile (most disadvantaged)	3 (0.2)	1,182 (26.5)	<0.001 for all
• 2nd quintile	1,693 (13.2)	1,085 (24.3)	
• 3rd quintile	4,827 (37.4)	1,476 (33.1)	
• 4th quintile	2,918 (22.6)	631 (14.1)	
• 5th quintile (least disadvantaged)	3,439 (26.6)	89 (2.0)	
Source of referral – Professional, n (%)			
• General practitioner	628 (4.9)	838 (18.4)	<0.001
• Specialist clinician	3,235 (25.2)	688 (15.1)	

• Outpatient Department clinician	534 (4.1)	137 (3.0)	
• Emergency Department clinician	7,650 (59.6)	2,527 (55.6)	
• Hospital clinician	89 (0.7)	67 (1.5)	
• Community health clinician	16 (0.1)	36 (0.8)	
• Others	106 (0.8)	33 (0.7)	
• Missing	572 (4.5)	221 (4.9)	
Mode of transport to hospital, n (%)			
• Private/public transport	6,193 (48.3)	2,952 (64.9)	<0.001
• Ambulance –patient transport only	542 (4.2)	88 (1.9)	
• Ambulance -emergency	4,938 (38.5)	884 (19.4)	
• Royal Flying Doctor Service	16 (0.1)	130 (2.9)	
• Other	115 (0.9)	156 (3.4)	
• Missing	1,026 (8.0)	337 (7.4)	
Comorbidities, n (%) *			
All ischaemic heart disease †	6,426 (49.9)	1,895 (42.1)	0.001
Acute myocardial infarction	2,242 (17.4)	636 (14.1)	<0.001
Unstable angina	1,987 (15.4)	485 (10.8)	<0.001
Hypertension	7,194 (55.9)	2,408 (53.5)	0.007
Atrial fibrillation	5,579 (43.3)	1,692 (37.6)	<0.001
Diabetes	4,104 (31.9)	1,543 (34.3)	0.003
Chronic kidney disease	2,851 (22.1)	918 (20.4)	0.015
Renal failure	415 (3.2)	181 (4.0)	0.012
COPD	2,600 (20.2)	1,146 (25.5)	<0.001
Cerebrovascular disease	1,404 (10.9)	391 (8.7)	<0.001
Rheumatic heart disease/rheumatic valvular heart disease	1,868 (14.5)	526 (11.7)	<0.001
Valvular heart disease, non-rheumatic	2,663 (20.7)	703 (15.6)	<0.001
Interventions, n (%)			
History of PCI	779 (6.1)	203 (4.5)	<0.001
History of CABG	342 (2.7)	118 (2.6)	0.891
Index PCI	228 (1.8)	36 (0.8)	<0.001
Index CABG	374 (2.9)	86 (1.9)	<0.001
Coronary angiography	6,003 (46.6)	1,711 (38.0)	<0.001
Charlson Index n (%)			
0	73 (0.6)	32 (0.7)	
1-2	5,780 (44.9)	2,158 (48.0)	0.001 for all
3-4	3,474 (27.0)	1,164 (25.9)	
>4	3,553 (27.6)	1,145 (25.4)	
Crude cumulative mortality			
30-day case fatality**	838 (6.6)	306 (6.9)	0.474
1-year mortality***	2,364 (20.5)	829 (20.7)	0.799
Mean presentations to ED within 1-year follow-up, n ±SD	2.8±3.1	4.9±5.7	<0.001

Continuous variables expressed as mean ± SD. Categorical variables expressed as proportions, n (%).
P-value is for difference between Metro and rural patients
* Patients could have multiple comorbidities.
† All ischaemic heart disease includes acute myocardial infarction.
PCI – percutaneous coronary intervention
CABG – coronary artery bypass graft
** Patients admitted in December 2009 were excluded from analysis
*** Year 2009 was used as a follow-up period.

Table 2. Step-wise risk adjustment for 30-day mortality and 1-year mortality (in 30-day survivors) in rural patients with index heart failure vs metropolitan patients.

Risk adjustment	Odds ratio [(OR), 95% CI]	p-value
Death at 30 days from index admission		
Unadjusted	1.05 (0.92-1.20)	0.487
Rural patients aAdjusted for:		
1. Age	1.16 (1.01-1.33)	0.035
2. Model 2 (socio-demographics): Age, sex, period, Aboriginality, SEIFA*, private insurance status	1.186 (1.01-1.383)	0.04736
3. Model 21 + Aboriginality, SEIFA, private insurance, emergency presentation, Charlson index	1.26 (1.07-1.49)	0.005
4. Model 32 + individual comorbidities**, interactions, insurance status, emergency presentation	1.26 (1.07-1.48)	0.007
5. Model 43 + PCI/CABG***	1.25 (1.06-1.48)	0.007
Death at 1-year in 30-day survivors	**Hazard ratio [(HR), 95% CI]**	**p-value**
Unadjusted	0.99 (0.90-1.09)	0.866
Rural patients aAdjusted for		
1. Age	1.11 (1.01-1.23)	0.030
1.2. Model 2- Age, sex, period, Aboriginality, SEIFA*, private insurance	1.0611 (0.95-1.201.01-1.22)	0.291037
2.3. Model 21 + Aboriginality, SEIFA, private insurance, emergency presentation, Charlson index	1.14 (1.02-1.289)	0.02730
3.4. Model 32 + individual comorbidities**, interactions	1.14 (1.02-1.28)	0.032
4.5. Model 43 + PCI/CABG***	1.13 (1.02-1.27)	0.040

*SEIFA – Socio-Economic Index for Areas
** Individual comorbidities adjusted in the models include: hypertension, atrial fibrillation, rheumatic heart disease, diabetes, chronic kidney disease, renal failure, unstable angina, acute myocardial infarction, other ischaemic heart disease, cerebrovascular disease, chronic obstructive pulmonary disease.
*** PCI/CABG – percutaneous coronary intervention/coronary artery bypass graft

Table 3. Sensitivity analysis showing step-wise risk adjustment for 30-day mortality and 1-year mortality (in 30-day survivors) in patients with index heart failure by level of residential location

Risk-adjustment	Regional WA		Remote/very remote WA	
Death at 30-day from index admission†	**Odds ratio (95% CI)**	**p-value**	**Odds ratio (95% CI)**	**p-value**
• Unadjusted	1.10 (0.94-1.29)	0.227	0.95 (0.76-1.19)	0.649
Adjusted for:				
1. Age	1.08 (0.99-1.17)	0.068	1.20 (1.07-1.36)	0.002
~~1.~~2. Age, sex, period, Aboriginality, SEIFA, private insurance ~~& period~~	1.172 (0.986-1.381)	0.083~~143~~	1.215 (0.939-1.597)	0.153~~058~~
~~2.~~3. Model 2~~1~~ + ~~Aboriginality, SEIFA, private insurance,~~ emergency presentation, Charlson index	1.24 (1.04-1.48)	0.015	1.34 (1.02-1.75)	0.033
~~3.~~4. Model 3~~2~~ + individual comorbidities, interactions	1.25 (1.04-1.49)	0.014	1.28 (0.98-1.68)	0.069
~~4.~~5. Model 4~~3~~ + PCI/CABG	1.24 (1.04-1.48)	0.016	1.29 (0.98-1.69)	0.071
Death at 1-year in 30-day survivors†				
• Unadjusted	1.09 (0.97-1.21)	0.136	0.81 (0.68-0.95)	0.011
Adjusted for:				
1. Age	1.13 (1.01-1.26)	0.030	1.07 (0.91-1.27)	0.419
~~1.~~2. Age, sex, ~~&~~ period, Aboriginality, SEIFA, private insurance	1.103 (0.971.01-1.246)	0.139034	0.931.07 (0.76-1.1490-1.26)	0.47757
~~2.~~3. Model 2~~1~~ + ~~Aboriginality, SEIFA, private insurance,~~ emergency presentation, Charlson index	1.17 (1.03-1.32)	0.0134	1.043 (0.865-1.276)	0.670747
~~3.~~4. Model 3~~2~~ + individual comorbidities, interactions	1.18 (1.04-1.33)	0.010	1.02 (0.84-1.24)	0.878
~~4.~~5. Model 4~~3~~ + PCI/CABG	1.17 (1.03-1.32)	0.014	1.02 (0.84-1.24)	0.870

† Patients with metropolitan residence as the reference group.

REFERENCES

1. Australian Institute of Health and Welfare. Rural, regional and remote health - Indicators of health. Canberra, AIHW, 2005. Cat. No. PHE 59.
2. AIHW 2010. Cardiovascular medicines and primary health care: a regional analysis. Canberra: AIHW, 2010.
3. Wakerman J, Humphreys JS. Rural health: why it matters. *Med J Aust*. 2002;**176**:457-8.
4. Dixon J, Welch N. Researching the rural-metropolitan health differential using the 'social determinants of health'. *Aust J Rural Health*. 2000;**8**:254-60.
5. Australian Bureau of Statistics. Population distribution, Aboriginal and Torres Strait Islander Australians, 2006. ABS, 2007 Cat. no. 3238.0.55.001.
6. Humphreys J, Hegney D, Lipscombe J, et al. Whither rural health? Reviewing a decade of progress in rural health. *Aust J Rural Health*. 2002;**10**:2-14.
7. Levy D, Kenchaiah S, Larson MG et al. Long-term trends in the incidence of and survival with heart failure. *N Engl J Med*. 2002;**347**:1397-402.
8. Muus KJ, Knudson A, Klug MG et al. Effect of post-discharge follow-up care on re-admissions among US veterans with congestive heart failure: a rural-urban comparison. *Rural Remote Health*. 2010;**10**:1447.
9. Gamble JM, Eurich DT, Ezekowitz JA, et al. Patterns of care and outcomes differ for urban versus rural patients with newly diagnosed heart failure, even in a universal healthcare system. *Circ Heart Fail*. 2011;**4**:317-23.
10. Jin Y, Quan H, Cujec B, et al. Rural and urban outcomes after hospitalization for congestive heart failure in Alberta, Canada. *J Card Fail*. 2003;**9**:278-85.
11. Holman CD, Bass AJ, Rosman DL, et al. A decade of data linkage in Western Australia: strategic design, applications and benefits of the WA data linkage system. *Aust Health Rev*. 2008;**32**:766-77.

12. Teng TH, Finn J, Hobbs M et al. Heart failure: incidence, case fatality, and hospitalization rates in Western Australia between 1990 and 2005. *Circ Heart Fail*. 2010;**3**:236-43.

13. Teng TH, Katzenellenbogen JM, Thompson SC et al. Incidence of first heart failure hospitalization and outcomes in Aboriginal and non-Aboriginal patients in Western Australia, 2000-2009. (In-press). 2013.

14. Teng T-H, Finn J, Hung J et al. A Validation Study: How Effective is The Hospital Morbidity Data as a Surveillance Tool for Heart Failure in Western Australia? *Aus NZ J Public Health*. 2008;**32**:405-7.

15. Australian Institute of Health and Welfare. Rural, regional and remote health: a guide to remoteness classification. Canberra, ACT: 2004. Cat no. PHE 53.

16. Geographic Information Systems EB, Public Health Division. Department of Health Health Geographical Classification, Version 4.0. I Perth: Department of Health, WA; 2013.

17. Australian Bureau of Statistics. Information paper: census of population and housing - socio-economic indexes for areas, Australia. Canberra: ABS, 2003. Cat no. 2033.055.001.

18. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;**40**:373-83.

19. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *J Clin Epidemiol*. 1993;**46**:1075-9.

20. Krumholz HM, Wang Y, Mattera JA et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with heart failure. *Circulation*. 2006;**113**:1693-701.

21. Krum H, Jelinek MV, Stewart S, et al. Guidelines for the prevention, detection and management of people with chronic heart failure in Australia 2006. *Med J Aust*. 2006;**185**:549-57.

22. Wakerman J, Humphreys JS, Wells RW, et al. Improving rural and remote health. *Med J Aust*. 2007;**186**:486.

23. Unger CC, Warren N, Canway R, et al. Type 2 diabetes, cardiovascular disease and the utilisation of primary care in urban and regional settings. *Rural Remote Health*. 2011;**11**:1795.

24. Clark RA, Eckert KA, Stewart S, et al. Rural and urban differentials in primary care management of chronic heart failure: new data from the CASE study. *Med J Aust*. 2007;**186**:441-5.

25. Stewart S, Pearson S, Horowitz JD. Effects of a home-based intervention among patients with congestive heart failure discharged from acute hospital care. *Arch Intern Med*. 1998;**158**:1067-72.

26. Davidson PM, Cockburn J, Newton PJ, et al. Can a heart failure-specific cardiac rehabilitation program decrease hospitalizations and improve outcomes in high-risk patients? *Eur J Cardiovasc Prev Rehabil*. 2010;**17**:393-402.

27. Digiacomo M, Davidson PM, Taylor KP, et al. Health information system linkage and coordination are critical for increasing access to secondary prevention in Aboriginal health: a qualitative study. *Quality in Primary Care*. 2010;**18**:17-26.

28. DiGiacomo ML, Thompson SC, Smith JS, et al. 'I don't know why they don't come': barriers to participation in cardiac rehabilitation. *Aust Health Rev*. 2010;**34**:452-7.

29. Thompson SC, Digiacomo ML, Smith JS, et al. Are the processes recommended by the NHMRC for improving Cardiac Rehabilitation (CR) for Aboriginal and Torres Strait Islander people being implemented?: an assessment of CR Services across Western Australia. *Australia and New Zealand Health Policy*. 2009;**6**:29.

30. Tideman P, Taylor AW, Janus E, et al. A comparison of Australian rural and metropolitan cardiovascular risk and mortality: the Greater Green Triangle and North West Adelaide population surveys. *BMJ open*. 2013;**3**:e003203.

31. Hindle D, McAuley I. The effects of increased private health insurance: a review of the evidence. *Aust Health Rev*. 2004;**28**:119-38.

32. Katzenellenbogen JM, Sanfilippo FM, Hobbs MS et al. Complex impact of remoteness on the incidence of myocardial infarction in Aboriginal and non-Aboriginal people in Western Australia. *Aust J Rural Health*. 2012;**20**:305-11.

33. Gausia K, Katzenellenbogen JM, Sanfilippo FM et al. Evidence-based prescribing of drugs for secondary prevention of acute coronary syndrome in Aboriginal and non-Aboriginal patients admitted to Western Australian hospitals. *Internal Medicine Journal*. 2014; in-press.

34 Teng T-H, Hung J, Finn J. The effect of evidence-based medication use on long-term survival in patients hospitalized for heart failure in Western Australia. *Med J Aust*. 2010;**192**:306-10.

Formatted: Space After: 0 pt, Line spacing: single

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Reported on page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	No
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6-8
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	All participants have first-ever heart failure hospitalisation
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	6, 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8, 10
		(*b*) Describe any methods used to examine subgroups and interactions	8, 10
		(*c*) Explain how missing data were addressed	16, 17
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods	No, loss to follow-up is minimal from previous studies done

taking account of sampling strategy	
(*e*) Describe any sensitivity analyses	Yes, page 10

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.