



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

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

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For peer review only

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.

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3 **Conclusions:** Rural patients with HF in WA have poorer risk-adjusted outcomes compared to
4 metropolitan patients. This finding has important implications for chronic disease management
5 and provision of health services in rural Australia.
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10 11 12 **Article summary**

13 14 15 *Strengths and limitations of this study*

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19 • The strengths of this study lie in the quality and near complete ascertainment of the short
20 and long-term mortality after first HF hospitalization using the Western Australia (WA)
21 linked administrative data.
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24 • A principal diagnosis of HF in the WA linked hospital morbidity data had been
25 previously validated against the Boston diagnostic criteria with a positive predictive
26 value of 92.4% for ‘definite’ HF.
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28
29 • We found a higher risk-adjusted 30-day and 1-year mortality (in 30-day survivors) in
30 rural (compared with metropolitan) patients following first HF hospitalisation in Western
31 Australia between 2000 and 2009. The mortality disparity between rural and metropolitan
32 patients persisted after adjustment for Aboriginality, other major socio-demographic
33 differences and comorbidities.
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36 • However, we do not have information to adjust for medications in our cohort and socio-
37 deprivation was derived using an area-based measure which could give rise to potential
38 misclassification.
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41 • The findings have implications for enhancing chronic disease management and secondary
42 prevention of HF in rural Western Australia.
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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.

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3 We examined differentials in short-term (30-day mortality) and 1-year mortality (in 30-day
4 survivors) following index (first-ever) hospitalisation for HF, between rural and metropolitan
5 patients resident in Western Australia.
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10 11 **Methodology**

12 *Study setting and data sources*

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14 The study was performed in Western Australia, which is the largest (by land mass) of six states
15 in Australia, with a land mass spanning 2.53 million km². Based on the 2006 census, about 27%
16 of the 2.5 million inhabitants in Western Australia lived in what is referred as regional and
17 remote Australia. Western Australia is also home to the third largest number of Aboriginal
18 Australians (13.2% of total Aboriginal population). Australia has a universal health care system
19 with free public acute hospital services, while allowing choice through a mix of public and private
20 health care service providers.
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33 Data were obtained from the Western Australian Data Linkage System, a population-based
34 electronic linked health database which has been used extensively for health-related
35 research[11]. The Hospital Morbidity Data Collection (HMDC), a core dataset of the data linkage
36 system, records information on hospital admissions throughout Western Australia (WA), and is
37 regularly audited for quality and accuracy. HMDC data are routinely linked to the Mortality
38 register using probabilistic matching with greater than 99% accuracy.[11]
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49 Our study was a population-based cohort using linked health data comprising all WA residents
50 aged 20-84 years who were admitted with a first hospitalisation for HF between 2000 and 2009,
51 [with no previous admissions in the past ten years] as described previously.[12, 13] Inclusion in
52 the study was based on a principal discharge diagnosis of HF or a secondary discharge
53 diagnosis of HF with a principal discharge diagnosis of a cardiovascular condition, excluding
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3 acute myocardial infarction (AMI). The coding for HF as a principal discharge diagnosis in the
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5 HMDC has been previously validated against the Boston diagnostic criteria with a positive
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7 predictive value of 92.4% for 'definite' HF.[14]
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11 Ethics approvals were obtained from the WA Aboriginal Health Ethics Committee and Human
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13 Research Ethics Committees of the Department of Health Western Australia and The University
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15 of Western Australia.
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20 21 **Geographical classification**

22 Using residential post codes, the Accessibility/Remoteness Index of Australia (ARIA)
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24 classification was used to define the five categories of residence based on road distance to
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26 service centres: major cities, inner regional, outer regional, remote and very remote.[15] For the
27
28 regression analysis, place of residence was dichotomised into metropolitan residence (based on
29
30 the greater Perth metropolitan city definition,[16] including urban and some of inner regional),
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32 and rural residence (remainder of inner regional, outer regional, remote and very remote). A
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34 sensitivity analysis was performed using three geographical locations: (i) metropolitan[16]; (ii)
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36 regional (remainder of inner regional and all of outer regional); and (iii) remote/very remote.
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42 Socio-Economic Indices for Areas (SEIFA)[17], were assigned to each patient based on
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44 residential postcodes and divided into quintiles, based on pre-defined cut-points. The first
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46 quintile (Q1) represents the most disadvantaged group and fifth quintile (Q5) the least.
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51 **Comorbidities, interventions and procedures**

52 Individual comorbidities within 5 years or concurrent with index HF hospitalization were
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54 identified: hypertension, atrial fibrillation, rheumatic fever and rheumatic heart disease, diabetes,
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56 valvular heart disease, chronic kidney disease, renal failure, chronic obstructive pulmonary
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3 disease (COPD), unstable angina, AMI, other ischaemic heart disease (IHD), and
4 cerebrovascular disease. A Charlson comorbidity score[18] was calculated for each index case
5 by applying a fixed 5-year look-back period using the HMDC. We used the Dartmouth-Manitoba
6 ICD code assignments[19] in calculating the Charlson score based on the original 17 Charlson
7 comorbidities. Percutaneous coronary intervention or coronary artery bypass grafting (CABG)
8 and coronary angiography were similarly identified.
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20 21 **Statistical analysis**

22 Descriptive analyses were used to characterise differences in the socio-demographics,
23 comorbidities, and interventions/procedures received between HF patients who reside in
24 metropolitan compared to rural areas. Means and standard deviations were calculated for
25 continuous variables whilst frequencies and proportions were derived for categorical data. The
26 Pearson chi-squared test was used to test for differences in categorical variables and the t-test
27 or Mann-Whitney test for continuous variables. Multivariable logistic regression was used to
28 determine predictors of death within 30 days, with odds ratios (ORs) and their 95% CIs
29 reported. Multivariable Cox regression was used to determine survival to 1 year in 30-day
30 survivors and hazard ratios (HRs) and their 95% CIs reported. All patients admitted between 1
31 January 2000 and 30 November 2009 were included for 30-day survival analysis. For survival
32 analysis to 1 year (from index admission), only patients admitted with their first HF between
33 2000 and 2008 were included.
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50 51 **Results**

52 Table 1 shows the geographic and socio-demographic characteristics of patients with first HF
53 hospitalisation living in metropolitan (n=12,880, 74.1%) and rural areas (n=4,499, 25.9%)
54 between 2000 and 2009. A total of 33.6% of rural patients were from remote or very remote
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3 areas and the remainder from regional areas. Rural compared with metropolitan patients were
4 significantly younger at first HF hospitalisation (mean age: 68 ± 13 vs 71 ± 12 years, $p<0.001$), and
5 more likely men (59.3 vs 57.2% , $p=0.017$). Aboriginal (including Torres Strait Islander) patients
6 comprised 17.2% of rural cases vs 1.9% of metropolitan cases. About 75% of rural HF patients
7 were seen at public rural regional or small district hospitals compared with less than 1% of
8 metropolitan patients. Rural patients were less likely to have private health insurance compared
9 to metropolitan patients (20.3% vs 32.6% , $p<0.001$). More than 50% of rural patients (vs 13.4%
10 metropolitan patients) were in the two lowest quintiles (index of most disadvantage) of SEIFA, a
11 proxy for socio-economic status.
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25 A higher proportion of rural patients had a Charlson index of 1-2 although a small but
26 significantly larger proportion of metropolitan patients (being older) scored >3 (Table 1). Despite
27 some statistical differences between metropolitan and rural patients, there was a high
28 prevalence of potential antecedent HF risk factors including ischaemic heart disease,
29 hypertension, atrial fibrillation, diabetes, chronic kidney disease, COPD, cerebrovascular
30 disease and rheumatic and non-rheumatic valvular heart disease in both subpopulations (see
31 Table 1). Rates of coronary interventions (prior to or on index admissions) were low overall but
32 significantly lower in rural patients. When adjusted for age, sex, period, Aboriginality and
33 Charlson comorbidity index, rural patients with HF were less likely to have coronary
34 angiography compared to metropolitan patients (risk-adjusted odds (OR)= 0.81 ; 95% CI 0.77 -
35 0.86 , $p<0.001$).
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51 Crude 30-day and 1-year cumulative all-cause mortality and unadjusted risk were not
52 significantly different between metropolitan and rural patients with first HF hospitalisation (Table
53 1, Table 2). After adjusting for age, sex and period, patients from rural areas had a higher risk of
54 30-day death (OR 1.16 , 95% CI 1.01 - 1.33) and 1-year death in 30-day survivors (HR 1.11 , 95%
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3 CI 1.01-1.22) (see Table 2). The difference in survival between rural and metropolitan patients
4 increased with further adjustment for Aboriginality, SEIFA (as proxy for socio-economic status),
5 private insurance status, emergency presentation and the Charlson comorbidity index, with OR
6 of 1.26 and HR of 1.14. The association between rurality and mortality persisted between the
7 two subpopulations after further adjustment to include other individual comorbidities of interest,
8 significant interaction effects and interventions (see Table 2).
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18 No significant interactions were found between sex and rurality; Aboriginality and rurality (as
19 location of residence). Further evaluation of mortality in men and women separately and in
20 younger (<55 years) and older patients showed similar odds/hazards of death at 30 days and 1-
21 year (in 30-day survivors) in rural patients compared with metropolitan patients.
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29 A sensitivity analysis using three levels of geographical residence (metropolitan, regional and
30 remote), indicates that regional patients had significantly higher adjusted 30-day and 1-year
31 mortality (in 30-day survivors) than metropolitan patients (Table 3). However, the slightly higher
32 OR for 30-day mortality in remote patients (1.29; 95% CI 0.98-1.69) did not reach significance in
33 the fully adjusted model, and the adjusted HR for one-year mortality (in 30-day survivors) was
34 not higher in remote patients (Table 3).
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44 **DISCUSSION**

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46 Heart failure is a complex, disabling, and potentially deadly clinical syndrome, of increasing
47 public health importance as the population ages.[20] Our study examined hospitalised patients
48 with 'first-ever' HF, and accordingly, a vast majority (>93%) were emergency presentations to
49 hospital. In this population-based cohort of patients, we found that a sizeable minority of
50 patients (26%) live in rural/remote WA. The majority of the rural patients with HF were from
51 areas of social disadvantage with limited or no access to specialist services for HF, as others
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3 have found.[21, 22] Rural area of residence was consistently associated with higher risk-
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5 adjusted odds and hazard of short-term mortality at 30 days and 1-year (in 30-day survivors)
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7 respectively, compared with metropolitan patients, even after controlling for socio-economic
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9 status, Aboriginality, private insurance status and risk factors. The same findings were observed
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11 in the subgroup analyses: both men and women who lived in rural/remote areas of WA; as well
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13 as in older patients aged 55 years and over.
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18 Earlier research by Clark et al[23] showed a significantly higher prevalence of congestive HF in
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20 rural compared to metropolitan areas among patients aged 60 years and over. Furthermore,
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22 rates of echocardiography for diagnosis or specialist referrals and rate of prescribing
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24 angiotensin-converting enzyme inhibitor drugs were consistently lower in rural compared with
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26 metropolitan areas.[23] Different pharmacotherapy patterns in rural and metropolitan Canadian
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28 patients with HF have also been reported.[9] We found that uptake of coronary angiography or
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30 interventions were lower in rural patients, consistent with the previous findings,[10, 23] although
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32 disparity in discharge medications was not examined in our study.
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38 Western Australia is geographically large, being the size of Western Europe, with much of its
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40 area sparsely populated. Accordingly, the tyranny of distance and lack of transport (as the
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42 interface between different entry points to the health care system) are major obstacles to
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44 accessing appropriate health care for rural West Australians. Access to appropriate specialist
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46 expertise also requires transfer between services and there are many reasons why such
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48 transfers may not occur. Moreover, there may be limited access to comprehensive primary
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50 health care services, poor integration between different levels of care and inadequate services
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52 to support ongoing home-based intervention and HF self-management[24] , HF-specific cardiac
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54 rehabilitation programs[25] and socio-culturally appropriate services.[26-28] Hence, the
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56 dimension of metro-rural divide in the context of Western Australia is larger than that which
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3 occurs in other states.[29] Issues of rural and remote health are much more complex than
4 merely the practice of health in another location[3] and are affected by issues such as workforce
5 shortages and retention of healthcare workers, higher out-of-pocket costs and the time and cost
6 of travel.[3]
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14 Rural and remote patients with HF differed considerably from metropolitan patients including
15 being younger, more socially disadvantaged and more likely to be Aboriginal. Despite Australia
16 having universal health insurance through Medicare which allows free access to public hospital
17 treatment and outpatient medical consultations and medications being subsidised, there remain
18 barriers to specialist consultations for socially disadvantaged groups, particularly where upfront
19 cash payments are required. An even more important disparity is the paucity of specialist
20 cardiology care in regional/remote areas. Evidence shows that increasing private health
21 insurance coverage in Australia has been associated with loss of equity after controlling for
22 other factors.[29, 30]
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36 Our results showed that despite further adjustments for demographics, SEIFA and private
37 health insurance status (both as a proxy for socio-economic status), Aboriginality, emergency
38 presentations, individual comorbidities and interventions, differential difference in mortality
39 outcomes persisted for rural patients compared to metropolitan patients. It is plausible that the
40 type of care received from regional, small district hospitals and/or rural primary care providers
41 compared with metropolitan hospitals and urban general practices has a differential impact on
42 mortality. Around 75% of the rural patients were managed at regional, small district hospitals,
43 while a vast majority of urban patients were treated in tertiary and private hospitals. There might
44 be another reason why fewer people have private insurance in rural areas – because there are
45 only 2 private hospitals in rural areas, and going in as a private patient in a public rural hospital
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3 offers little advantage. Hence, rural residents may not see a need for private insurance, and
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5 they probably think the likelihood of being admitted to a metro private hospital is low.
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10 In the sensitivity analysis with the three levels for residential location, regional patients showed
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12 increased risk-adjusted ORs/HRs of 30-day mortality and 1-year mortality (in 30-day survivors).
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14 The association for remote/very remote patients was marginally significant (for 30-day mortality)
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16 possibly because of a lack of power. However, previous work by Katzenellenbogen et al[31]
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18 found that some older groups living in remote areas had lower MI rates than metropolitan
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20 residents, suggesting a possible migration effect of remote patients with heart disease moving
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22 to regional/metro centres. The data from the current study may reflect such a phenomenon, with
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24 remote HF patients moving to more accessible centres after their incident event and thus
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26 benefiting through improved 1-year survival.
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31 Our results are consistent with other studies from Canada and the US which also reported
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33 worse outcomes in rural versus metropolitan patients with HF,[8-10] The same rural-
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35 metropolitan differential in WA was reported for the incidence of myocardial infarction in
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37 Western Australia.[31] However, conflicting evidence was reported from a CVD risk study on
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39 South-West Victoria and North-West Adelaide, Australia.[29] That study examined
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41 cardiovascular mortality rates without comprehensive adjustment and only a small proportion of
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43 the patients examined were Aboriginal.[29] There is also a contextual difference in that HF has
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45 high mortality with patients often presenting with heavy comorbidity burden.
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51 The strengths of this study lie in the quality and near complete ascertainment of the short- and
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53 long-term mortality after first HF hospitalization using linked administrative data in Western
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55 Australia,[11] and the previous validation with respect to a principal diagnosis of HF.[14]
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57 However, socio-deprivation was derived using an area-based measure which gives rise to
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3 potential misclassification at an individual level. We have no information as to why people
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5 choose not to have private health insurance. Our study also lacked information on use of
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7 medications in our cohort.
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10 11 12 **Conclusions**

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14 This study highlights the impact of geographical or spatial isolation on mortality outcomes in HF
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16 patients as the first step in understanding rural-urban differences. From the health policy
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18 perspective, the higher rural mortality likely points to the inequalities in the availability and
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20 access to appropriate medical care, rather than compositional differences in rural and
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22 metropolitan patients with HF. Rural Western Australia is not homogeneous and the proportion
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24 of Aboriginal people increases with remoteness. This has implications for the provision of
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26 collaborative models of care for chronic disease management and secondary prevention of HF
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28 in rural areas.
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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(%)			
• 1 st quintile (most disadvantaged)	3 (0.2)	1,182 (26.5)	<0.001 for all
• 2 nd quintile	1,693 (13.2)	1,085 (24.3)	
• 3 rd quintile	4,827 (37.4)	1,476 (33.1)	
• 4 th quintile	2,918 (22.6)	631 (14.1)	
• 5 th 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)	0.001 for all
1-2	5,780 (44.9)	2,158 (48.0)	
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 \pm 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		
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	
	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Death at 30-day from index admission[†]				
• Unadjusted	1.10 (0.94-1.29)	0.227	0.95 (0.76-1.19)	0.649
<i>Adjusted for:</i>				
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
<i>Adjusted for:</i>				
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 (0.85-1.26)	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.

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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

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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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	6-8
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods	No, loss to follow-up is minimal from previous studies done

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taking account of sampling strategy
(e) Describe any sensitivity analyses

Yes, page 10

Continued on next page

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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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —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
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*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

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Manuscripts

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

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

17 *Strengths and limitations of this study*

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

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3 We examined differentials in 30-day mortality and 1-year mortality (in 30-day survivors)
4 following index (first-ever) hospitalisation for HF, between rural and metropolitan patients
5 resident in Western Australia.
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10 11 **Methodology**

12 *Study setting and data sources*

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14 The study was performed in Western Australia, which is geographically the largest of six states
15 in Australia, with a land mass spanning 2.53 million km². Based on the 2006 census, about 27%
16 of the 2.5 million inhabitants in Western Australia lived in what is referred as regional and
17 remote Australia. Western Australia is also home to the third largest number of Aboriginal
18 Australians (13.2% of total Aboriginal population). Australia has a universal health care system
19 with free public acute hospital services, while allowing choice through a mix of public and private
20 health care service providers.
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33 Data were obtained from the Western Australian Data Linkage System, a population-based
34 electronic linked health database which has been used extensively for health-related
35 research[11]. The Hospital Morbidity Data Collection (HMDC), a core dataset of the data linkage
36 system, records information on hospital admissions throughout Western Australia (WA), and is
37 regularly audited for quality and accuracy. HMDC data are routinely linked to the Mortality
38 register using probabilistic matching with greater than 99% accuracy.[11]
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49 The Emergency Department data Collection (EDDC) containing data on emergency department
50 (ED) activity in Western Australia's public and private hospitals (under contract with the WA
51 Government) was used to examine re-presentations to ED within 1-year of follow-up from index
52 admission of HF.
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3 Ours was a population-based cohort study using linked health data comprising all WA residents
4 aged 20-84 years who were admitted with a first hospitalisation for HF between 2000 and 2009,
5 [with no previous admissions in the past ten years] as described previously.[12, 13] Inclusion in
6 the study was based on a principal discharge diagnosis of HF or a secondary discharge
7 diagnosis of HF with a principal discharge diagnosis of a cardiovascular condition, excluding
8 acute myocardial infarction (AMI). The coding for HF as a principal discharge diagnosis in the
9 HMDC has been previously validated against the Boston diagnostic criteria with a positive
10 predictive value of 92.4% for 'definite' HF.[14]
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23 Ethics approvals were obtained from the WA Aboriginal Health Ethics Committee and Human
24 Research Ethics Committees of the Department of Health Western Australia and The University
25 of Western Australia.
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31 **Geographical classification**

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33 Using residential post codes, the Accessibility/Remoteness Index of Australia (ARIA)
34 classification was used to define the five categories of residence based on road distance to
35 service centres: major cities, inner regional, outer regional, remote and very remote.[15] For the
36 regression analysis, place of residence was dichotomised into metropolitan residence (based on
37 the greater Perth metropolitan city definition,[16] including urban and some of inner regional),
38 and rural residence (remainder of inner regional, outer regional, remote and very remote). A
39 sensitivity analysis was performed using three geographical locations: (i) metropolitan[16]; (ii)
40 regional (remainder of inner regional and all of outer regional); and (iii) remote/very remote.
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53 Socio-Economic Indices for Areas (SEIFA)[17], were assigned to each patient based on
54 residential postcodes and divided into quintiles, based on pre-defined cut-points. The first
55 quintile (Q1) represents the most disadvantaged group and fifth quintile (Q5) the least.
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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.

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

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9 Table 1 shows the geographic and socio-demographic characteristics of patients with first HF
10 hospitalisation living in metropolitan (n=12,880, 74.1%) and rural areas (n=4,499, 25.9%)
11 between 2000 and 2009. A total of 33.6% of rural patients were from remote or very remote
12 areas and the remainder from regional areas. Rural compared with metropolitan patients were
13 significantly younger at first HF hospitalisation (mean age: 68±13 vs 71±12 years, p<0.001), and
14 more likely men (59.3 vs 57.2%, p=0.017). Aboriginal (including Torres Strait Islander) patients
15 comprised 17.2% of rural cases vs 1.9% of metropolitan cases. About 75% of rural HF patients
16 were seen at public regional or small district hospitals compared with less than 1% of
17 metropolitan patients. Rural patients were less likely to have private health insurance compared
18 to metropolitan patients (20.3% vs 32.6%, p<0.001). More than 50% of rural patients (versus
19 13.4% metropolitan patients) were in the two lowest quintiles (index of most disadvantage) of
20 SEIFA, a proxy for socio-economic status.
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38 Profile of care prior to the index hospitalisation for HF and pre-hospital emergency medical
39 service (EMS) coverage by ambulance was different in both sub-populations (Table 1).
40 Metropolitan (versus rural) patients were more likely to be managed by specialist clinicians
41 (25.2% vs 15.1% rural); by contrast, more rural patients were cared for by GPs (18.4% versus
42 4.9% metropolitan). Metropolitan (versus rural) patients were more likely to be transported by
43 EMS ambulance to admitting hospitals (38.5% versus 19.4%). About 65% of rural patients
44 depended on private/public transport to get to admitting hospitals. Notably, rural (versus
45 metropolitan) patients were also more likely (49.1% versus 20.4%) to present to EDs (for any
46 condition) with tri-age scores of 4 or 5 (for semi-urgent or non-urgent cases) during the 1-year
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3 follow-up, suggesting EDs being used to fill the gaps in primary care or specialist services in
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5 rural areas.
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10 A higher proportion of rural patients had a Charlson index of 1-2 although a small but
11 significantly larger proportion of metropolitan patients (being older) scored >3 (Table 1). Despite
12 some statistical differences between metropolitan and rural patients, there was a high
13 prevalence of potential antecedent HF risk factors including ischaemic heart disease,
14 hypertension, atrial fibrillation, diabetes, chronic kidney disease, COPD, cerebrovascular
15 disease and rheumatic and non-rheumatic valvular heart disease in both subpopulations (see
16 Table 1). Rates of coronary interventions (prior to or on index admissions) were low overall but
17 significantly lower in rural patients. When adjusted for age, sex, period, Aboriginality and
18 Charlson comorbidity index, rural patients with HF were less likely to have coronary
19 angiography compared to metropolitan patients (risk-adjusted odds (OR)=0.81; 95% CI 0.77-
20 0.86, $p<0.001$).
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36 Crude 30-day and 1-year cumulative all-cause mortality and unadjusted risk were not
37 significantly different between metropolitan and rural patients with first HF hospitalisation (Table
38 1, Table 2). After age adjustment only, patients from rural areas had a higher risk of 30-day
39 death [OR 1.16 (95% CI 1.01-1.33)] and 1-year death in 30-day survivors [HR 1.11 (95% CI
40 1.01-1.23), see Table 2]. The difference in survival between rural and metropolitan patients
41 increased with further adjustment for socio-demographic differences including Aboriginality,
42 SEIFA (as proxy for socio-economic status), private insurance status, emergency presentation,
43 and the Charlson comorbidity index, with OR of 1.26 and HR of 1.14. The association between
44 rurality and mortality persisted between the two subpopulations after further adjustment to
45 include other individual comorbidities of interest, significant interaction effects and interventions
46 (see Table 2). The addition of the weighted Charlson index to the 30-day model (using a
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3 variation of the administrative claims model[20] improved the 'c' statistic (under the ROC curve)
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5 from 0.656 to 0.714.
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7 No significant interactions were found between sex and rurality; Aboriginality and rurality (as
8 location of residence). Further evaluation of mortality in men and women separately and in
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10 younger (<55 years) and older patients showed similar odds/hazards of death at 30 days and 1-
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12 year (in 30-day survivors) in rural patients compared with metropolitan patients.
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17 A sensitivity analysis using three levels of geographical residence (metropolitan, regional and
18 remote), indicates that regional patients had significantly higher adjusted 30-day and 1-year
19 mortality (in 30-day survivors) than metropolitan patients (Table 3). However, the slightly higher
20 OR for 30-day mortality in remote patients (1.29; 95% CI 0.98-1.69) did not reach significance in
21 the fully adjusted model, and the adjusted HR for one-year mortality (in 30-day survivors) was
22 not higher in remote patients (Table 3).
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32 **DISCUSSION**

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35 Heart failure is a complex, disabling, and potentially deadly clinical syndrome, of increasing
36 public health importance as the population ages.[21] Our study examined hospitalised patients
37 with 'first-ever' HF, and accordingly, a vast majority (>93%) were emergency presentations to
38 hospital. In this population-based cohort of patients, we found that a sizeable minority of
39 patients (26%) live in rural/remote WA. The majority of the rural patients with HF were from
40 areas of social disadvantage with limited or no access to specialist services for HF, as others
41 have found.[22, 23] Rural area of residence was consistently associated with higher risk-
42 adjusted odds and hazard of short-term mortality at 30 days and 1-year (in 30-day survivors)
43 respectively, compared with metropolitan patients, even after controlling for socio-economic
44 status, Aboriginality, private insurance status and risk factors. The same findings were observed
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3 in the subgroup analyses: both men and women who lived in rural/remote areas of WA; as well
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5 as in older patients aged 55 years and over.
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10 Earlier research by Clark et al[24] showed a significantly higher prevalence of congestive HF in
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12 rural compared to metropolitan areas among patients aged 60 years and over. Furthermore,
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14 rates of echocardiography for diagnosis or specialist referrals and rate of prescribing
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16 angiotensin-converting enzyme inhibitor drugs were consistently lower in rural compared with
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18 metropolitan areas.[24] Different pharmacotherapy patterns in rural and metropolitan Canadian
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20 patients with HF have also been reported.[9] We found that receipt of coronary angiography or
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22 interventions were lower in rural patients, consistent with the previous findings,[10, 24] although
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24 disparity in discharge medications was not examined in our study.
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29 Western Australia is geographically large, being the size of Western Europe, with much of its
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31 area sparsely populated. Accordingly, the tyranny of distance and lack of transport (as the
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33 interface between different entry points to the health care system) are major obstacles to
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35 accessing appropriate health care for rural West Australians. Access to appropriate specialist
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37 expertise also requires transfer between services and there are many reasons why such
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39 transfers may not occur. Moreover, there may be limited access to comprehensive primary
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41 health care services, poor integration between different levels of care and inadequate services
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43 to support ongoing home-based intervention and HF self-management[25] , HF-specific cardiac
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45 rehabilitation programs[26] and socio-culturally appropriate services.[27-29] Hence, the
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47 dimension of metro-rural divide in the context of Western Australia is larger than that which
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49 occurs in other states.[30] Issues of rural and remote health are much more complex than
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51 merely the practice of health in another location[3] and are affected by issues such as workforce
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53 shortages and retention of healthcare workers, higher out-of-pocket costs and the time and cost
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55 of travel.[3]
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5 Rural and remote patients with HF differed considerably from metropolitan patients including
6 being younger, more socially disadvantaged and more likely to be Aboriginal. Despite Australia
7 having universal health insurance through Medicare which allows free access to public hospital
8 treatment and outpatient medical consultations and medications being subsidised, there remain
9 barriers to specialist consultations for socially disadvantaged groups, particularly where upfront
10 cash payments are required. An even more important disparity is the paucity of specialist
11 cardiology care in regional/remote areas. This is evident from the differences in profiles of care
12 between the two sub-populations and the findings that showed rural patients were utilising EDs
13 to fill the gaps in the primary health care and the specialist services in rural areas. Other
14 evidence shows that increasing private health insurance coverage in Australia has been
15 associated with loss of equity after controlling for other factors.[30, 31]
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31 The heterogeneity in the different geographical areas needs to be highlighted. However, our
32 results showed that despite further adjustments for demographics, SEIFA and private health
33 insurance status (both as a proxy for socio-economic status), Aboriginality, emergency
34 presentations, individual comorbidities and interventions, differential difference in mortality
35 outcomes persisted for rural patients compared to metropolitan patients. It is plausible that the
36 type of care received from regional, small district hospitals and/or rural primary care providers
37 compared with metropolitan hospitals and urban general practices has a differential impact on
38 mortality. Around 75% of the rural patients were managed at regional, small district hospitals,
39 while a vast majority of urban patients were treated in tertiary and private hospitals. There might
40 be another reason why fewer people have private insurance in rural areas – because there are
41 only 2 private hospitals in rural areas, and going in as a private patient in a public rural hospital
42 offers little advantage. Hence, rural residents may not see a need for private insurance, and
43 they probably think the likelihood of being admitted to a metro private hospital is low.
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6 In the sensitivity analysis with the three levels for residential location, regional patients showed
7 increased risk-adjusted ORs/HRs of 30-day mortality and 1-year mortality (in 30-day survivors).
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9 The association for remote/very remote patients was marginally significant (for 30-day mortality)
10 possibly because of a lack of power. However, previous work by Katzenellenbogen et al[32]
11 found that some older groups living in remote areas had lower MI rates than metropolitan
12 residents, suggesting a possible migration effect of remote patients with heart disease moving
13 to regional/metro centres. The data from the current study may reflect such a phenomenon, with
14 remote HF patients moving to more accessible centres after their incident event and thus
15 benefiting through improved 1-year survival.
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27 Our results are consistent with other studies from Canada and the US which also reported
28 worse outcomes in rural versus metropolitan patients with HF,[8-10] The same rural-
29 metropolitan differential in WA was reported for the incidence of myocardial infarction in
30 Western Australia.[32] However, conflicting evidence was reported from a CVD risk study on
31 South-West Victoria and North-West Adelaide, Australia.[30] That study examined
32 cardiovascular mortality rates without comprehensive adjustment and only a small proportion of
33 the patients examined were Aboriginal.[30] There is also a contextual difference in that HF has
34 high mortality with patients often presenting with heavy comorbidity burden.
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47 The problem of inequalities in health burden and access to health care related to rurality and
48 remoteness is a common theme across many countries including high socioeconomic countries
49 such as Australia and Canada. It is therefore an important issue that is relevant to health policy,
50 health service delivery and health care planning in many countries beyond the local context.
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3 The strengths of this study lie in the quality and near complete ascertainment of the short- and
4 long-term mortality after first HF hospitalization using linked administrative data in Western
5 Australia,[11] and the previous validation with respect to a principal diagnosis of HF.[14]
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7 However, socio-deprivation was derived using an area-based measure which gives rise to
8 potential misclassification at an individual level. We have no information as to why people
9 choose not to have private health insurance. Our study also lacked information on use of
10 medications in our cohort. However, in a separate study undertaken by our team[33], the
11 authors found adjusted evidence-based prescription at discharge for patients with acute
12 coronary syndrome was significantly lower in district hospitals versus metropolitan teaching
13 hospitals (OR 0.51, 95% CI 0.32-0.82), as well also in patients with regional versus metropolitan
14 residence (OR 0.55, 95% CI 0.39-0.77). This finding is also likely applicable to the uptake and
15 adherence to evidence-based therapy for HF patients discharged from non-tertiary and rural
16 care hospitals. We have previously shown that the discharge prescription of evidence-based HF
17 medications had a significant impact on subsequent survival[34].
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36 **Conclusions**

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38 This study highlights the impact of geographical or spatial isolation on mortality outcomes in HF
39 patients as the first step in understanding rural-urban differences. From the health policy
40 perspective, the higher rural mortality likely points to the inequalities in the availability and
41 access to appropriate medical care, rather than compositional differences in rural and
42 metropolitan patients with HF. Rural Western Australia is not homogeneous and the proportion
43 of Aboriginal people increases with remoteness. This has implications for the provision of
44 collaborative models of care for chronic disease management and secondary prevention of HF
45 in rural areas.
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Extra data is available by emailing Tiew-Hwa Katherine Teng at katherine.teng@uwa.edu.au

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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 \pm SD (years)	70.8 \pm 11.7	67.5 \pm 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 \pm SD	7.1 \pm 8.6	6.4 \pm 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(%)			
• 1 st quintile (most disadvantaged)	3 (0.2)	1,182 (26.5)	<0.001 for all
• 2 nd quintile	1,693 (13.2)	1,085 (24.3)	
• 3 rd quintile	4,827 (37.4)	1,476 (33.1)	
• 4 th quintile	2,918 (22.6)	631 (14.1)	
• 5 th 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

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5 Continuous variables expressed as mean \pm SD. Categorical variables expressed as proportions, n (%).

6 P-value is for difference between Metro and rural patients

7 * Patients could have multiple comorbidities.

8 † All ischaemic heart disease includes acute myocardial infarction.

9 PCI – percutaneous coronary intervention

10 CABG – coronary artery bypass graft

11 ** Patients admitted in December 2009 were excluded from analysis

12 *** Year 2009 was used as a follow-up period.

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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		
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	
	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Death at 30-day from index admission[†]				
• Unadjusted	1.10 (0.94-1.29)	0.227	0.95 (0.76-1.19)	0.649
<i>Adjusted for:</i>				
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
<i>Adjusted for:</i>				
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.

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

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60**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

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9 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.](#)

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14 **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.

21 22 23 Article summary

24 25 *Strengths and limitations of this study*

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28 • 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.
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31 • 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.
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36 • 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.
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41 • 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.
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46 • The findings have implications for enhancing chronic disease management and secondary prevention of HF in rural Western Australia.
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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.

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9 We examined differentials in ~~short term~~ (30-day mortality) and 1-year mortality (in 30-day
10 survivors) following index (first-ever) hospitalisation for HF, between rural and metropolitan
11 patients resident in Western Australia.
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14 15 16 **Methodology**

17 *Study setting and data sources*

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19 The study was performed in Western Australia, which is geographically the largest (~~by land~~
20 ~~mass~~) of six states in Australia, with a land mass spanning 2.53 million km². Based on the 2006
21 census, about 27% of the 2.5 million inhabitants in Western Australia lived in what is referred as
22 regional and remote Australia. Western Australia is also home to the third largest number of
23 Aboriginal Australians (13.2% of total Aboriginal population). Australia has a universal health
24 care system with free public acute hospital services, while allowing choice through a mix of
25 public and private health care service providers.
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33 Data were obtained from the Western Australian Data Linkage System, a population-based
34 electronic linked health database which has been used extensively for health-related
35 research[11]. The Hospital Morbidity Data Collection (HMDC), a core dataset of the data linkage
36 system, records information on hospital admissions throughout Western Australia (WA), and is
37 regularly audited for quality and accuracy. HMDC data are routinely linked to the Mortality
38 register using probabilistic matching with greater than 99% accuracy.[11]
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45 The Emergency Department data Collection (EDDC) containing data on emergency department
46 (ED) activity in Western Australia's public and private hospitals (under contract with the WA
47 Government) was used to examine re-presentations to ED within 1-year of follow-up from index
48 admission of HF.
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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.

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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~~ 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

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9 [follow-up, suggesting EDs being used to fill the gaps in primary care or specialist services in](#)
10 [rural areas.](#)
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14 A higher proportion of rural patients had a Charlson index of 1-2 although a small but
15 significantly larger proportion of metropolitan patients (being older) scored >3 (Table 1). Despite
16 some statistical differences between metropolitan and rural patients, there was a high
17 prevalence of potential antecedent HF risk factors including ischaemic heart disease,
18 hypertension, atrial fibrillation, diabetes, chronic kidney disease, COPD, cerebrovascular
19 disease and rheumatic and non-rheumatic valvular heart disease in both subpopulations (see
20 Table 1). Rates of coronary interventions (prior to or on index admissions) were low overall but
21 significantly lower in rural patients. When adjusted for age, sex, period, Aboriginality and
22 Charlson comorbidity index, rural patients with HF were less likely to have coronary
23 angiography compared to metropolitan patients (risk-adjusted odds (OR)=0.81; 95% CI 0.77-
24 0.86, p<0.001).
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35 Crude 30-day and 1-year cumulative all-cause mortality and unadjusted risk were not
36 significantly different between metropolitan and rural patients with first HF hospitalisation (Table
37 1, Table 2). After [age adjustment only, patients from rural areas had a higher risk of 30-day](#)
38 [death \[OR 1.16 \(95% CI 1.01-1.33\)\] and 1-year death in 30-day survivors \[HR 1.11 \(95% CI](#)
39 [1.01-1.23\), see Table 2\].](#) ~~for age, sex and period, patients from rural areas had a higher risk of~~
40 ~~30 day death (OR 1.16, 95% CI 1.01-1.33) and 1 year death in 30 day survivors (HR 1.11, 95%~~
41 ~~CI 1.01-1.22) (see Table 2).~~ The difference in survival between rural and metropolitan patients
42 increased with further adjustment for [socio-demographic differences including](#) Aboriginality,
43 SEIFA (as proxy for socio-economic status), private insurance status, emergency presentation,
44 and the Charlson comorbidity index, with OR of 1.26 and HR of 1.14. The association between
45 rurality and mortality persisted between the two subpopulations after further adjustment to
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9 include other individual comorbidities of interest, significant interaction effects and interventions
10 (see Table 2). The addition of the weighted Charlson index to the 30-day model (using a
11 variation of the administrative claims model[20] improved the 'c' statistic (under the ROC curve)
12 from 0.656 to 0.714.
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18 No significant interactions were found between sex and rurality; Aboriginality and rurality (as
19 location of residence). Further evaluation of mortality in men and women separately and in
20 younger (<55 years) and older patients showed similar odds/hazards of death at 30 days and 1-
21 year (in 30-day survivors) in rural patients compared with metropolitan patients.
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26 A sensitivity analysis using three levels of geographical residence (metropolitan, regional and
27 remote), indicates that regional patients had significantly higher adjusted 30-day and 1-year
28 mortality (in 30-day survivors) than metropolitan patients (Table 3). However, the slightly higher
29 OR for 30-day mortality in remote patients (1.29; 95% CI 0.98-1.69) did not reach significance in
30 the fully adjusted model, and the adjusted HR for one-year mortality (in 30-day survivors) was
31 not higher in remote patients (Table 3).
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38 DISCUSSION

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40 Heart failure is a complex, disabling, and potentially deadly clinical syndrome, of increasing
41 public health importance as the population ages.[21] Our study examined hospitalised patients
42 with 'first-ever' HF, and accordingly, a vast majority (>93%) were emergency presentations to
43 hospital. In this population-based cohort of patients, we found that a sizeable minority of
44 patients (26%) live in rural/remote WA. The majority of the rural patients with HF were from
45 areas of social disadvantage with limited or no access to specialist services for HF, as others
46 have found.[22, 23] Rural area of residence was consistently associated with higher risk-
47 adjusted odds and hazard of short-term mortality at 30 days and 1-year (in 30-day survivors)
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9 respectively, compared with metropolitan patients, even after controlling for socio-economic
10 status, Aboriginality, private insurance status and risk factors. The same findings were observed
11 in the subgroup analyses: both men and women who lived in rural/remote areas of WA; as well
12 as in older patients aged 55 years and over.
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17 Earlier research by Clark et al[24] showed a significantly higher prevalence of congestive HF in
18 rural compared to metropolitan areas among patients aged 60 years and over. Furthermore,
19 rates of echocardiography for diagnosis or specialist referrals and rate of prescribing
20 angiotensin-converting enzyme inhibitor drugs were consistently lower in rural compared with
21 metropolitan areas.[24] Different pharmacotherapy patterns in rural and metropolitan Canadian
22 patients with HF have also been reported.[9] We found that receiptuptake of coronary
23 angiography or interventions were lower in rural patients, consistent with the previous
24 findings.[10, 24] although disparity in discharge medications was not examined in our study.
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33 Western Australia is geographically large, being the size of Western Europe, with much of its
34 area sparsely populated. Accordingly, the tyranny of distance and lack of transport (as the
35 interface between different entry points to the health care system) are major obstacles to
36 accessing appropriate health care for rural West Australians. Access to appropriate specialist
37 expertise also requires transfer between services and there are many reasons why such
38 transfers may not occur. Moreover, there may be limited access to comprehensive primary
39 health care services, poor integration between different levels of care and inadequate services
40 to support ongoing home-based intervention and HF self-management[25] , HF-specific cardiac
41 rehabilitation programs[26] and socio-culturally appropriate services.[27-29] Hence, the
42 dimension of metro-rural divide in the context of Western Australia is larger than that which
43 occurs in other states.[30] Issues of rural and remote health are much more complex than
44 merely the practice of health in another location[3] and are affected by issues such as workforce
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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, 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

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9 offers little advantage. Hence, rural residents may not see a need for private insurance, and
10 they probably think the likelihood of being admitted to a metro private hospital is low.
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14 In the sensitivity analysis with the three levels for residential location, regional patients showed
15 increased risk-adjusted ORs/HRs of 30-day mortality and 1-year mortality (in 30-day survivors).
16 The association for remote/very remote patients was marginally significant (for 30-day mortality)
17 possibly because of a lack of power. However, previous work by Katzenellenbogen et al[32]
18 found that some older groups living in remote areas had lower MI rates than metropolitan
19 residents, suggesting a possible migration effect of remote patients with heart disease moving
20 to regional/metro centres. The data from the current study may reflect such a phenomenon, with
21 remote HF patients moving to more accessible centres after their incident event and thus
22 benefiting through improved 1-year survival.
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31 Our results are consistent with other studies from Canada and the US which also reported
32 worse outcomes in rural versus metropolitan patients with HF,[8-10] The same rural-
33 metropolitan differential in WA was reported for the incidence of myocardial infarction in
34 Western Australia.[32] However, conflicting evidence was reported from a CVD risk study on
35 South-West Victoria and North-West Adelaide, Australia.[30] That study examined
36 cardiovascular mortality rates without comprehensive adjustment and only a small proportion of
37 the patients examined were Aboriginal.[30] There is also a contextual difference in that HF has
38 high mortality with patients often presenting with heavy comorbidity burden.
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47 The problem of inequalities in health burden and access to health care related to rurality and
48 remoteness is a common theme across many countries including high socioeconomic countries
49 such as Australia and Canada. It is therefore an important issue that is relevant to health policy,
50 health service delivery and health care planning in many countries beyond the local context.
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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.

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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

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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 \pm SD (years)	70.8 \pm 11.7	67.5 \pm 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 \pm SD	7.1 \pm 8.6	6.4 \pm 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(%)			
• 1 st quintile (most disadvantaged)	3 (0.2)	1,182 (26.5)	<0.001 for all
• 2 nd quintile	1,693 (13.2)	1,085 (24.3)	
• 3 rd quintile	4,827 (37.4)	1,476 (33.1)	
• 4 th quintile	2,918 (22.6)	631 (14.1)	
• 5 th quintile (least disadvantaged)	3,439 (26.6)	89 (2.0)	
Source of referral – Professional, n (%)			
• <u>General practitioner</u>	<u>628 (4.9)</u>	<u>838 (18.4)</u>	<u><0.001</u>
• <u>Specialist clinician</u>	<u>3,235 (25.2)</u>	<u>688 (15.1)</u>	

• <u>Outpatient Department clinician</u>	<u>534 (4.1)</u>	<u>137 (3.0)</u>	
• <u>Emergency Department clinician</u>	<u>7,650 (59.6)</u>	<u>2,527 (55.6)</u>	
• <u>Hospital clinician</u>	<u>89 (0.7)</u>	<u>67 (1.5)</u>	
• <u>Community health clinician</u>	<u>16 (0.1)</u>	<u>36 (0.8)</u>	
• <u>Others</u>	<u>106 (0.8)</u>	<u>33 (0.7)</u>	
• <u>Missing</u>	<u>572 (4.5)</u>	<u>221 (4.9)</u>	
Mode of transport to hospital, n (%)			
• <u>Private/public transport</u>	<u>6,193 (48.3)</u>	<u>2,952 (64.9)</u>	<u><0.001</u>
• <u>Ambulance –patient transport only</u>	<u>542 (4.2)</u>	<u>88 (1.9)</u>	
• <u>Ambulance -emergency</u>	<u>4,938 (38.5)</u>	<u>884 (19.4)</u>	
• <u>Royal Flying Doctor Service</u>	<u>16 (0.1)</u>	<u>130 (2.9)</u>	
• <u>Other</u>	<u>115 (0.9)</u>	<u>156 (3.4)</u>	
• <u>Missing</u>	<u>1,026 (8.0)</u>	<u>337 (7.4)</u>	
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
<u>Mean presentations to ED within 1-year follow-up, n ±SD</u>	<u>2.8±3.1</u>	<u>4.9±5.7</u>	<u><0.001</u>

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Continuous variables expressed as mean \pm 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.

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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 a 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	1.186 (1.01-1.383)	0.04736
3. Model 24 + 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		
Unadjusted	0.99 (0.90-1.09)	0.866
Rural patients a Adjusted for:		
1. Age	1.11 (1.01-1.23)	0.030
2. Model 2- Age, sex, period, Aboriginality, SEIFA*, private insurance	1.0644 (0.95-1.204-1.22)	0.291037
3. Model 24 + Aboriginality, SEIFA*, private insurance, emergency presentation, Charlson index	1.14 (1.02-1.289)	0.02730
4. Model 32 + individual comorbidities**, interactions	1.14 (1.02-1.28)	0.032
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

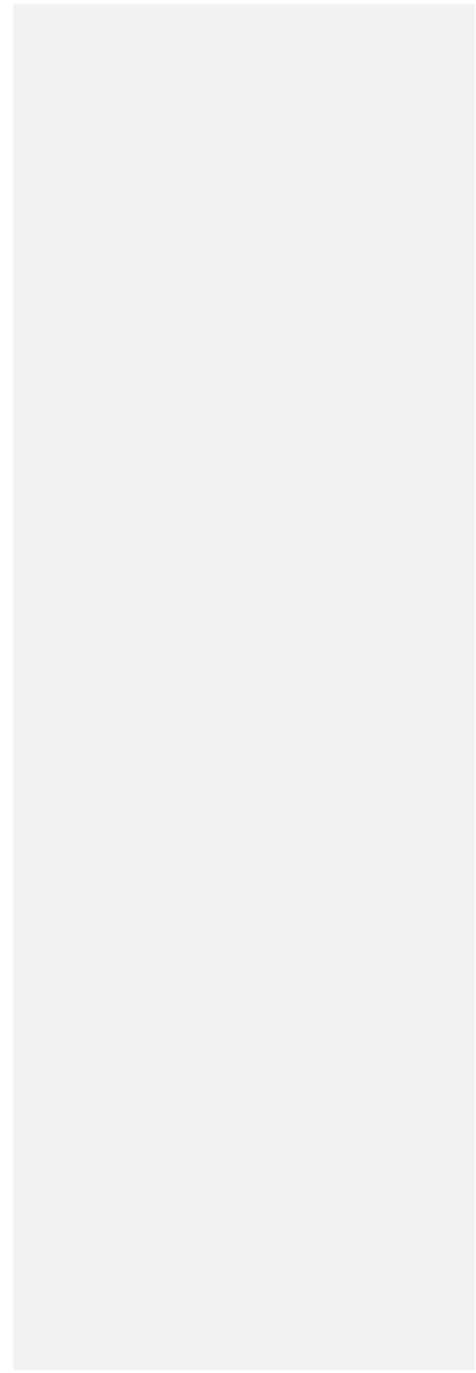
Table 3. Sensitivity analysis showing step-wise risk adjustment for 30-day mortality and 1-year mortality (in 30-day survivors) in patients with index heart failure by level of residential location

Risk-adjustment	Regional WA		Remote/very remote WA	
	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Death at 30-day from index admission†				
• Unadjusted	1.10 (0.94-1.29)	0.227	0.95 (0.76-1.19)	0.649
<i>Adjusted for:</i>				
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 & period	1.17 (0.98-1.38)	0.083	1.21 (0.93-1.59)	0.153
3. Model 2 + Aboriginality, SEIFA, private insurance, 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
<i>Adjusted for:</i>				
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 + Aboriginality, SEIFA, private insurance, 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

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† Patients with metropolitan residence as the reference group.

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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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	6-8
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods	No, loss to follow-up is minimal from previous studies done

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taking account of sampling strategy
(e) Describe any sensitivity analyses

Yes, page 10

Continued on next page

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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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —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
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*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.