ORIGINAL RESEARCH ARTICLE

Outcomes following heart failure hospitalization in a regional Australian setting between 2005 and 2014

Mohammed S. Al-Omary[1,2,3], Arshad A. Khan[1], Allan J. Davies[1], Peter J. Fletcher[1,2], Dawn Mcivor[1], Bruce Bastian[1], Christopher Oldmeadow[2,3], Aaron L. Sverdlov[1,2,3], John R. Attia[1,2,3] and Andrew J. Boyle[1,2,3]*

[1]*John Hunter Hospital, Hunter New England Health, Newcastle, NSW, Australia;* [2]*The University of Newcastle, Newcastle, NSW, Australia;* [3]*Hunter Medical Research Institute, Newcastle, NSW, Australia*

Abstract

Aims   The aim of the current study is to examine 10 year trends in mortality and readmission following heart failure (HF) hospitalization in metropolitan and regional Australian settings.

Methods and results   We identified all index HF hospitalizations in the Hunter New England region from 2005 to 2014, using a 10 year 'look back' period. The primary endpoint was a composite of all-cause mortality or all-cause readmission at 1 year. Secondary endpoints included all-cause mortality, all-cause readmission, and HF readmission at 30 days and 1 year. We used logistic regression to explore the predictors of the composite outcome of either all-cause death or readmission at 1 year. There were 12 114 patients admitted with a first episode of HF between 2005 and 2014, followed up until death or the end of 2015. The mean age was 78 ± 12 years and 49% (*n* = 5906) were male. A total of 4831 (40%) resided in regional areas and the remainder in metropolitan areas. One hundred sixty-eight patients (1.4%) were Aboriginal. Approximately 69% of patients had either died or been readmitted for any cause within 12 months of their index event. The 30 day and 1 year all-cause mortality rates were 13% and 32%, respectively, with no change in the trend over the study period. Age, socio-economic disadvantage, ischaemic heart disease, renal failure, and chronic lower respiratory disease were predictors of the primary endpoint.

Conclusions   Heart failure hospitalizations are followed by high rates of death or readmission. There was no change in this composite endpoint over the 10 year study period.

Introduction

Heart failure (HF) is a worldwide health problem, with an estimated 37.7 million people affected in 2010.[1] HF carries a heavy burden on both patients and health systems due to high mortality rates and frequent hospitalizations.[2,3] In the USA, it is estimated that 5.7 million people (2.2%) lived with this chronic disease between 2009 and 2012.[4] In Australia, HF is a major cause of cardiovascular hospitalizations and death.[5] The estimated prevalence of HF in Australia is between 1% and 2%, with prevalence increasing with age and variation seen based on gender and remoteness.[6] HF hospitalization resulted in the occupancy of 1.4 million bed-days per year in Australia, costing the health system more than one billion dollars annually.[7,8]

Heart failure is associated with substantial in-hospital and post-discharge mortality, as well as high rates of readmission.[9] The 1 year mortality rate following hospitalization is between 25% and 30% in developed countries with decreasing trends in the last few decades.[10,11] However, the last HF mortality trend study in Australia only included patients up to 2009.[12] A National Heart Foundation report recently highlighted the paucity of information regarding HF rehospitalization rates.[13] There is disparity in HF services between metropolitan and regional Australia with little information about HF outcomes in regional areas.[14] HF will continue to

be a significant burden on patients and healthcare systems in the coming years.[15]

Given the lack of Australian contemporary data to assist healthcare resource planners, our primary aim was to examine the 1 year mortality and readmission rates of patients who are discharged following an index admission for HF and to find predictors of these outcomes. Our secondary aim was to perform survival analysis of all-cause mortality, all-cause readmission, and HF readmission.

Methods

As described before,[16] we identified all index hospitalizations with HF in the Hunter New England (HNE) region over a 10 year period from January 2005 to December 2014. The HNE region of New South Wales, Australia, covers an area of over 130 000 km^2 and has a population of approximately 910 000, of whom approximately 45% live in metropolitan areas and 55% in regional or rural settings. The HNE local health district (LHD) has one major metropolitan teaching hospital, a mix of several large regional centres, and many smaller regional centres. Approximately 15% of the population were born overseas and about 5% of the population are Aboriginal and Torres Strait Islanders.[17]

Dataset and heart failure cohort

We prospectively collect outcome data on all hospitalized patients with cardiac diseases and stroke in the HNE LHD hospitals (see Supporting Information for more details on the dataset). Records with an *International Statistical Classification of Diseases and Related Health Problems* 10th edition (ICD10) code for HF (I-50) as a principal diagnosis or one of the first three secondary diagnoses on discharge were extracted and linked to the New South Wales state registry of births and deaths. For remoteness, we divided the HNE LHD area into regional and metropolitan depending on the patient's residential address.

To identify index HF admissions, we applied a 10 year look back period to insure no HF-related admission in the previous 10 years. We included patients with HF in the first four discharge diagnoses, in order to increase sensitivity. Limiting the study to patients with HF as the primary diagnosis resulted in similar trends (see Supporting Information). For readmission, we excluded dialysis episodes (day only), inpatient rehabilitation, and patients transferred to other hospitals. Those with in-hospital mortality were also not considered when ascertaining readmissions. We defined HF readmission if the HF ICD10 code (I-50) was in the first four diagnoses. The ethics approval for the study was granted by HNE Human Research Ethics Committee (approval number: AU201603-15).

Co-morbidities and socio-economic state

We identified the ICD10 codes for hypertension, diabetes mellitus, renal failure, chronic lower respiratory disease, atrial fibrillation, and ischaemic heart disease on discharge documentation of the index hospital admission (see *Table 1*). We used Socio-Economic Index of Relative Socioeconomic Disadvantage for Areas codes, which are calculated by the Australian Bureau of Statistics as a measure of disadvantage. We used National Heart Foundation Heart Maps to match the quantile score and local government area (LGA).[18]

Statistical analysis

We used median and interquartile range to summarize continuous variables and numbers and percentages for binary variables. Logistic regression, Poisson regression, and negative binomial regression were used to examine trends in mortality and readmission rates over time. We used logistic regression to examine predictors of 30 day and 1 year outcomes. For multivariable logistic regression analysis, predictors were included if the univariate analysis *P*-value was ≤0.2. We used sex-stratified Kaplan–Meier survival analysis to examine time to the composite of all-cause readmission or all-cause mortality, all-cause mortality, all-cause readmission, and HF readmission. We used 0.05 as the level of

Table 1 Demographic features and co-morbidities

Demographic features and co-morbidities	No. (*n* = 12 114)
Patient demographics	
HF 150.0 code (congestive heart failure)	9561 (79)
HF 150.1 code (left ventricular failure)	2120 (17)
HF 150.9 code (heart failure, unspecified)	433 (4)
Age (years), median (IQR)	80 (72–86)
Age groups, number (%)	
15–64 years	1535 (13)
65–74 years	2191 (18)
≥75 years	8388 (69)
Male, number (%)	5906 (49)
Regional, number (%)	4831 (40)
Aboriginal and Torres Strait Islander, *n* (%)	168 (1.4)
Length of stay in days, median (IQR)	5 (3–10)
Socio-Economic Indexes for Areas, number (%)	
First quintile (most disadvantaged)	0
Second quintile	1111 (8)
Third quintile	2026 (17)
Fourth quintile	8977 (75)
Fifth quintile (least disadvantaged)	0
Co-morbidities with ICD10 codes, number (%)	
Hypertension	5223 (43)
Ischaemic heart disease	3361 (28)
Atrial fibrillation (I-48)	3742 (31)
Diabetes mellitus	2733 (23)
Renal failure	2804 (23)
Chronic lower respiratory disease	2441 (20)

HF, heart failure; ICD10, *International Statistical Classification of Diseases and Related Health Problems* 10th edition; IQR, interquartile range.

significance. Data were analysed using Stata Version 14.1 (Stata Corp, College Station, Texas).

Results

Heart failure cohort

The Hunter HF cohort includes 22 500 consecutive admissions to hospitals in the HNE LHD with a diagnosis of HF between 2005 and 2014; 578 were excluded because they resided outside the HNE area, and 71 were excluded because their index admission was in a nursing home facility in the HNE LHD, leaving 21 851 patients who had an HF admission. With application of a 10 year look back (1995–2004), 12 114 patients were deemed to have an index HF admission between 2005 and 2014 and included in the final analysis. The median age was 80 years, and just under half were male (49%, n = 5906). The median age differed between men (79 years) and women (82 years) ($P \leq 0.001$).

There was no change in median age over the study period (P = 0.36). More than one-third of the study cohort resided in regional areas (n = 4831), and the remainder resided in metropolitan areas. The most common co-morbidity was hypertension (43%). A total of 10 089 (83%) had at least one co-morbidity apart from HF (see *Table 1* for demographics and co-morbidities). Twelve-month follow-up was available for all patients (see *Figure 1*).

Primary endpoint

A total of 8384 (69%) reached the primary endpoint (composite of all-cause readmission or all-cause mortality) at 1 year. This rate did not change over the 10 year study time period (relative change is 1.003; 95% confidence interval is 0.995–1.01; P = 0.48). The predictors for the primary endpoint were older age, ischaemic heart disease, renal failure, and chronic lower respiratory disease. Atrial fibrillation, hypertension, improved socio-economic status, and female gender were associated with reduced event rates at 1 year (see *Table 2*).

Secondary endpoints

Composite 30 day all-cause mortality or all-cause readmission

A total of 3573 patients (29%) had death or readmission within 30 days. The crude 30 day rate did not change over the study period (P = 0.505). The predictors for 30 day events in the multivariable logistic regression were older age, ischaemic heart disease, and renal failure. Female gender and hypertension were also protective against 30 day events.

Figure 1 Patient selection for inclusion in the final analysis. HNE = Hunter New England. HF = heart failure.
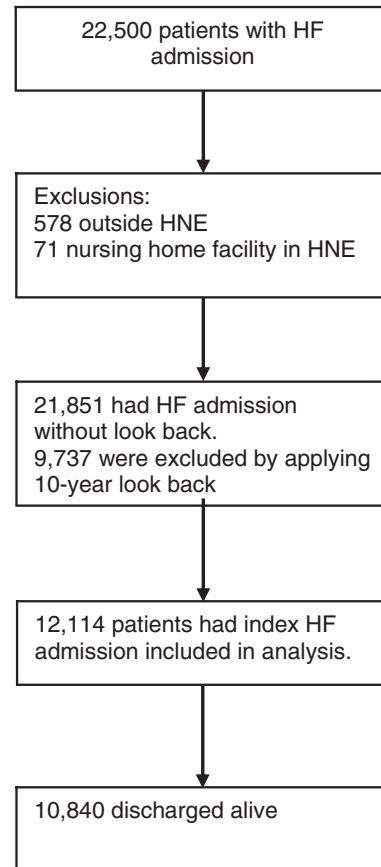
All-cause mortality

The overall 30 day and 1 year mortality rates were 13% and 32%, respectively. There was no significant change in these rates over the study period (P = 0.096 and P = 0.718, respectively). For 1 year mortality, age and renal failure were predictors of death, while female gender, living in regional areas, hypertension, and atrial fibrillation were associated with increased likelihood of survival.

All-cause readmission

Of the 10 840 patients who were discharged alive, 2120 (20%) were readmitted within 30 days and 6312 (58%) were readmitted within 1 year. There was a 1.8% increase per year, on average, in the 30 day all-cause readmission rate (95% confidence interval is 0.3–3.3%, $P \leq 0.018$), but there was no significant change in 1 year all-cause readmission rate over the study period (P = 0.36). Age, indigenous status, ischaemic heart disease, renal failure, chronic respiratory diseases, and diabetes were predictors of 1 year all-cause readmissions (see Supporting Information). Female gender and socio-economic advantage were protective for 1 year all-cause readmission.

Table 2 Univariate and multivariable logistic regression analysis of predictors of 1 year primary outcome

| | Outcome: 1 year all-cause mortality or all-cause readmission | | | |
| | Univariate | | Multivariable | |
Predictors	Odds ratio	95% CI (*P*-value)	Odds ratio	95% CI (*P*-value)
Calendar year during study	1.01	0.99–1.02 (0.213)	—**	—**
Age (per 10 years)	1.24	1.2–1.28 (<0.001)	1.27	1.23–1.32 (<0.001)
Female	0.89	0.82–0.96 (0.003)	0.84	0.77–0.91 (<0.001)
Regional (vs. metropolitan)	1.08	0.99–1.17 (0.051)	0.96	0.86–1.08 (0.542)
ATSI	1.05	0.75–1.46 (0.771)	—**	—**
SEIFA (vs. Quantile 2)				
Quantile 3	0.9	0.76–1.06 (0.2)	0.9	0.76–1.06 (0.2)
Quantile 4	0.79	0.69–0.91 (0.001)	0.75	0.63–0.89 (0.001)
Hypertension	0.93	0.86–1.01 (0.069)	0.84	0.77–0.91 (<0.001)
IHD	1.14	1.04–1.24 (0.004)	1.11	1.02–1.22 (0.018)
AF	0.9	0.82–0.97 (0.01)	0.88	0.81–0.96 (0.003)
DM	1.06	0.97–1.17 (0.179)	1.09	0.96–1.2 (0.095)
RF	1.71	1.55–1.89 (<0.001)	1.7	1.54–1.89 (<0.001)
CLRD	1.25	1.13–1.38 (<0.001)	1.3	1.19–1.45 (<0.001)

AF, atrial fibrillation; ATSI, Aboriginal Torres Strait Islander; CI, confidence interval; CLRD, chronic lower respiratory disease; DM, diabetes mellitus; IHD, ischaemic heart disease; RF, renal failure; SEIFA, Socio-Economic Indexes for Areas.
**Not included in the Multivariable model because the Univariate *P*-value is more than 0.2.

Heart failure readmission

Of the 10 840 patients who were discharged alive, 955 (9%) and 2888 (27%) had HF readmission in the 30 day and 1 year periods, respectively. There was no significant change in the 30 day HF readmission rate; however, 1 year HF readmission decreased from 30% in 2005 to 24% in 2014 (*P* < 0.001). HF readmission was responsible for 46% of 30 day and 1 year all-cause readmission.

Advanced age, indigenous status, ischaemic heart disease, renal failure, chronic lower respiratory diseases, and diabetes were predictors of 1 year HF readmission. Women had a lower risk of HF readmission.

Time-to-event analysis

Out of 12 114 patients with incident HF admission, 11 113 (92%) reached the composite endpoint of death or readmission over the period of follow-up (see *Figure 2*). Fifty per cent of the events occurred within the first 4 months; by 2 years, approximately 80% had experienced a primary endpoint. A total of 8114 (67%) died during the follow-up period and 50% died within 2.7 years.

In-hospital mortality occurred in 1274 patients (10.5%). Out of the 10 840 who survived the index hospitalization, 50% had all-cause readmission within 210 days. A total of 4615 had HF readmission (43%), and 50% had an HF readmission within 4 years. There was no difference between men and women (see *Figure 2*).

Discussion

Our study estimates several clinically useful prognostic parameters for HF patients in an area that is broadly representative

of Australian demographics. We confirm significant mortality and morbidity following HF hospitalization. The rate of all-cause death or readmission did not change significantly over the study period.

Outcomes

The rates of death and readmission are high, on par with many cancers.[3] There was no statistically significant change in the adjusted and unadjusted primary endpoints over the study period. Our data are similar to other published studies and registries. In Australia, Stewart *et al.*'s randomized controlled trial of home-based intervention showed a 1 year event rate (death or unplanned readmission) of 74% in the usual care arm and 57% in the home-based intervention.[19] In Australia, Robertson *et al.*[7] showed 28 day and 1 year readmission or death rates of 32% and 72%, respectively. In the USA, the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure registry[20] revealed 60–90 day event rates of 36.1% in HF with reduced ejection fraction (HFrEF) and 35.3% in HF with preserved ejection fraction (HFpEF). The high rate of primary outcome may be due to old age and the high prevalence of co-morbidities.[19] This is also similar to mortality rates in the same region from a previous study.[21]

Over the study period, there was no statistically significant change in the trend of 30 day and 1 year all-cause mortality (13% and 32%, respectively). Previous national studies revealed a decline in all-cause mortality,[12,22] and a similar pattern was noted internationally.[10] However, there was no statistically significant change in trend in our study. Despite improvements in device and pharmacological treatment of HFrEF, there has been no major changes in treatment for HFpEF, which accounts for about 50% of HF

Figure 2 Kaplan–Meier failure function graphs showing (A) primary endpoint (all-cause readmission or all-cause mortality), (B) all-cause mortality, (C) all-cause readmission, and (D) heart failure (HF) readmission.
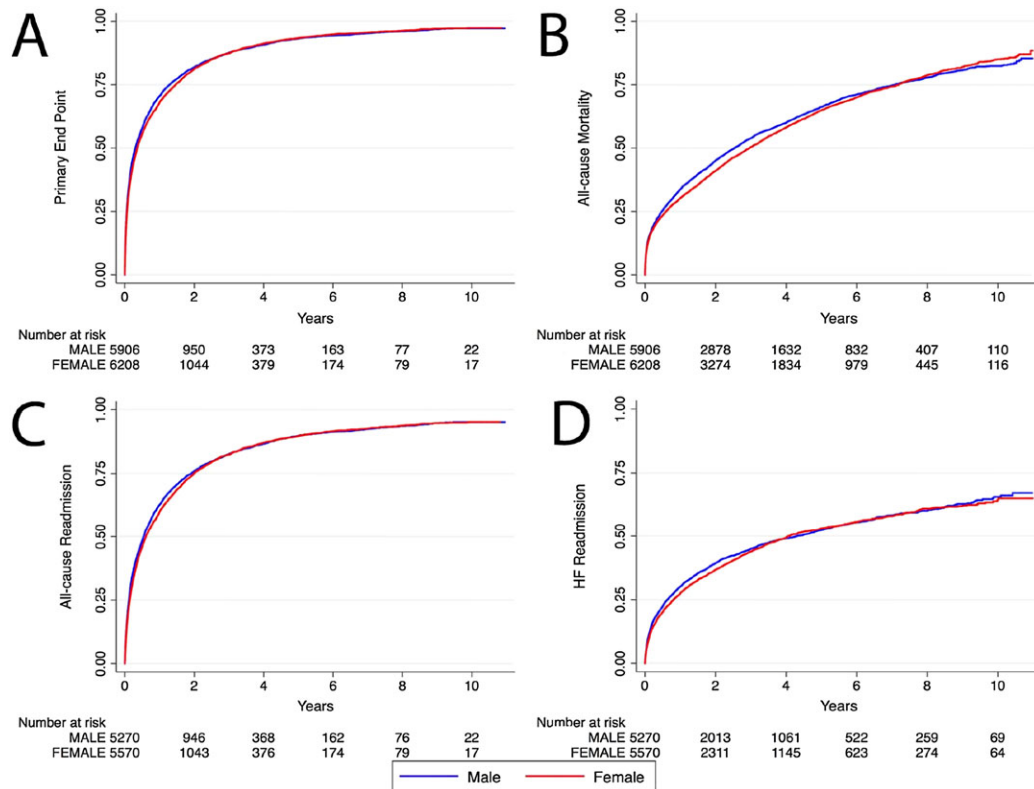
patients. This might be one of the possible explanations to the lack of improvement of HF outcomes over the study period.[23] In addition, the median age of our cohort was high, perhaps hitting a ceiling in our ability to delay HF mortality.

Heart failure patients are old with at least one co-morbidity apart from HF. The probability of co-morbidities increased over time and with age. In addition, advances in prevention may have delayed the onset of HF. These shifting demographics highlight the importance of involving geriatric medicine in HF management.[7,24]

The 30 day and 1 year all-cause readmission rates were 20% and 58%, respectively, with nearly half of all readmissions due to HF. Our results are slightly lower than those of Robertson et al.[7] who found 28 day and 1 year all-cause readmission rates of 25% and 63%, respectively, of which 40% were due to HF. A recent study[25] comparing all-cause readmission between HFpEF and HFrEF showed similar rates, with 30 day readmission rates of 20% and 19%, respectively, while the 1 year readmission rates were 55% and 58%, respectively. Despite the decrease in age-standardized HF hospitalization over the last few decades in some countries,[2,22,26,27] the rates increased in other countries like Germany and Spain.[28,29] In fact, the absolute number of

hospitalizations increased in terms of both all-cause and HF readmissions.[16,29] In addition, US data showed no difference in the overall HF hospitalization from 2000 to 2010. However, the rate of HF hospitalization increased with advanced age.[30] This might be the reason for the high rate of all-cause rehospitalization.

Predictors and co-morbidities

The mean age in our study is slightly higher than international studies but is similar to recent Australian studies where the mean age was 77 years.[31,32] We had an equal distribution among men and women, similar to other national and international figures.[9] Among the predictors of outcomes, age and female gender always predicted outcomes. Hypertension was protective for the primary endpoint and all-cause mortality. Although hypertension is one of the major risk factors and cause of HF, the protective effect might be attributed to the ongoing management of hypertension. Indeed, atrial fibrillation has been associated with worse outcomes in HF.[33] However, this is not a universal association. In the Vasodilator Heart Failure Trial, the presence of AF was not associated with a worse outcome in 1427 patients with

mild to moderate HF.[34] Two other relatively small studies also revealed no independent prognostic significance of atrial fibrillation in patients with HF.[35,36] Another observational study from New Zealand showed all-cause mortality was significantly lower in the atrial fibrillation cohort compared with the sinus rhythm cohort.[37] The fact that the point estimates in our dataset were similar between the univariate and multivariate models suggests it is not due to confounding. Renal failure and chronic respiratory diseases were predictors of poor outcomes. The percentage with co-morbidities in our study is similar to other national and international studies,[7,20,22] except for hypertension, which was lower in our study. However, there might be an under-reporting of co-morbidities or a lack of clear diagnostic criteria from administrative data collection.[38] There is a complex interaction between co-morbidities and HF. Co-morbidities can cause HF, lead to exacerbations of HF, or can affect patient adherence to medication.[39] Greater co-morbidities were a predictor of mortality or readmission.[19] Interestingly, mortality was less in HF patients residing in regional areas compared with metropolitan areas (odds ratio = 0.92, $P = 0.042$). This is in contrast to a recent study by Teng et al.,[40] however; they adjusted for age only, whereas we adjusted for age, co-morbidities, gender, and socio-economic status.

Limitation and strength

A limitation of our study is the lack of differentiation between HFpEF and HFrEF. In addition, the reliability of study conclusions is dependent on the accuracy of the diagnostic coding in the medical record. We chose all-cause mortality and all-cause readmission as our primary endpoint because these outcomes are the most objective. A validation study using similar datasets from Western Australia showed a positive predictive value of 99.5 for diagnosing HF.[41] The lack of evidence-based treatment records in our cohort is another limitation. However, a strength of our study is the long-term follow-up of the cohort. Further, it is one of the largest studies defining HF outcomes in regional Australia. In addition, by applying a 10 year look back, we identified HF patients at the initial stage of the disease and decreased heterogeneity. The outcome of the cohort without 10 year look back was analysed and showed similar result to the above results (see Supporting Information).

Conclusion

Heart failure hospitalizations in Australia are followed by high rates of death or readmission. Patients with HF are usually old with at least one other co-morbidity apart from HF. Advanced age and co-morbidities are generally predictors of poor prognosis.

Conflict of interest

None declared.

Funding

Supporting information

Additional Supporting Information may be found online in the supporting information tab for this article.

Table S1. Predictors of 1 year all-cause mortality, 1 year all-cause readmission, and 1 year HF readmission.
Table S2. Univariate and multivariable analysis of predictors 1 year. (A) Primary outcome and all-cause mortality, (B) all-cause readmission and HF readmission.
Table S3. Demographics.
Table S4. Univariate and multivariable analysis in cohort with *principal diagnosis of HF* of predictors 1 year (A) primary outcome and all-cause mortality, (B) all-cause readmission and HF readmission.
Figure S1. Kaplan–Meier failure function graphs of *entire cohort* without look-back showing: (A) Primary endpoint (all-cause readmission or all-cause mortality). (B) All-cause mortality. (C) All-cause readmission. (D) HF readmission.
Figure S2. Kaplan–Meier failure function graphs of cohort with *principal diagnosis* of HF showing: (A) Primary endpoint (all-cause readmission or all-cause mortality). (B) All-cause mortality. (C) All-cause readmission. (D) HF readmission.

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