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ORIGINAL RESEARCH ARTICLE

Epidemiology of heart failure: Study of Heart failure in the Australian Primary carE setting (SHAPE)

Danny Liew[1]*, Ralph G. Audehm[2], Deepak Haikerwal[3], Peter Piazza[4], A. Munro Neville[5], Kevin Lim[6], Richard W. Parsons[5] and Andrew P. Sindone[7]

[1]*School of Public Health and Preventive Medicine, Monash University, 553 St Kilda Rd, Melbourne, VIC 3004, Australia;* [2]*Department of General Practice, University of Melbourne, Melbourne, VIC, Australia;* [3]*HeartWest, Melbourne, VIC, Australia;* [4]*Five Dock Family Medical Practice, Sydney, NSW, Australia;* [5]*AusTrials, Brisbane, QLD, Australia;* [6]*Novartis Pharmaceuticals Pty. Ltd, Sydney, NSW, Australia;* [7]*Heart Failure Unit and Department of Cardiac Rehabilitation, Concord Hospital, Sydney, NSW, Australia*

Abstract

Aims At present, there is no robust information on the prevalence and incidence of heart failure (HF) in the general Australian community. The present study of primary care data sought to estimate the prevalence and incidence of HF in the community and to describe the demographic and clinical profile of Australians with HF.

Methods and results We undertook a retrospective cohort study based on analysis of anonymized medical records of adult patients cared for at 43 Australian general practices between 1 July 2013 and 30 June 2018. Data were extracted from coded and uncoded fields in electronic medical records. The prevalence and annual incidence of HF were calculated, along with 95% confidence intervals, using the 'active' population of people who were regular attenders at the practices. Age-standardized estimates were also derived using the 2017 Australian population as reference. The mean age of the population with HF was 69.8 years, 50.6% were female, and mean body mass index was 31.2 kg/m^2. The age-standardized prevalence was 2.199% [95% confidence interval (CI): 2.168–2.23%], and the age-standardized annual incidence was 0.348% (95% CI: 0.342–0.354%). These estimates accord with almost 420 000 people living with HF in Australia in 2017, and >66 000 new cases of HF occurring that year. Only 18.9% of patients with definite HF had this formally captured as a 'diagnosis' in their medical record. HF was more frequent among those of lower socio-economic status.

Conclusions HF is common in Australia. The majority of HF patients do not have this diagnosis optimally noted in their primary care medical records.

Keywords Health services; Epidemiology; Heart failure; Quality and outcomes of care; Electronic medical records

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**Correspondence to: Danny Liew, School of Public Health and Preventive Medicine, Monash University, 553 St Kilda Rd, Melbourne VIC 3004, Australia.*
Email: danny.liew@monash.edu

Introduction

Heart failure (HF) is a condition of major significance across the world. In Australia, the continued ageing of the population, improved survival from acute coronary syndromes (a major aetiological factor for HF),[1,2] and the rising prevalence of other risk factors such as hypertension[3] are expected to further increase the burden of HF on the health care system in general and on primary care more specifically.[4]

Chan *et al*. recently applied epidemiological estimates from overseas to Australian population data and estimated that 480 000 Australians currently have HF with reduced ejection fraction (HFrEF), and >60 000 new diagnoses are made every year.[5] The authors applied epidemiological estimates from overseas, because at present, there is no robust information about the prevalence and incidence of HF drawn from the general Australian community. There is also little information about the demographic and clinical profiles of patients with HF in the general Australian community. This information is important for health care planning, as well as for establishing a baseline against which to compare the results of future epidemiological studies. Furthermore, insight is needed into areas in which the management of HF can be improved.

The Study of Heart failure in the Australian Primary carE setting (SHAPE) is a retrospective cohort study of primary care data that seeks to estimate the prevalence and annual incidence of HF in the general Australian community and to describe the demographic and key clinical profiles of people in the general community with HF.

Methods

SHAPE is a retrospective cohort study based on analysis of existing medical records of patients aged ≥18 years cared for at participating general practices between 1 July 2013 and 30 June 2018. Participating practices were those within the Healius network (previously known as Primary Health Care) that use the Medical Director electronic medical record. This group comprised 43 centres from a network of 71; the remaining 28 practices were using software other than Medical Director. All practices provided fully subsidized care to their patients (known as 'bulk-billing'). Individual patient level data for people who had findings suggestive of HF or an aetiological factor for HF were extracted from general practitioner (GP) practice software by Healius and provided in an anonymized manner for analyses.

The primary endpoints of interest were the prevalence and incidence of HF, stratified by age and gender. We also described the demographic and clinical profiles of the HF population, (aetiological factors, co-morbidities, symptoms of HF, examination findings, and medication use) and health care utilization. Among patients aged ≥18 years, HF was identified by (i) a specified diagnosis of HF, or (ii) ongoing treatment with a HF-specific medication, or (iii) clinical features of HF, or (iv) pathology test results indicative of HF. Details of these selection criteria are provided in Parsons *et al.*[6] The population was then stratified into three groups on the basis of a hierarchy of selection criteria into 'definite HF', 'probable HF', and 'possible HF', as specified in *Table 1*.

The prevalence and annual incidence of HF were calculated, along with their 95% confidence intervals (CIs). Both crude and age-standardized estimates were derived, the latter using the Australian population in 2017[7] as reference. Incident cases were based on first 'diagnosis' HF, that is, no evidence of HF in prior records.

Two methods were used to obtain denominator data for prevalence and incidence. In the primary analyses, data comprised only 'active' patients, those with at least three visits per 2 year period.[8] This accounted for under-estimation of prevalence and incidence that would have arisen from denominator data being inflated by one-off or infrequent attendances. In secondary analyses, both numerator and denominators were based on the total number of patients seen at the participating GP clinics during each calendar year for the period under study. These included people who were not regular patients of the centres.

For the calculation of incidence, we assumed that new cases were those that appeared in the database from July 2014 onwards (excluding those that were diagnosed in the first year of the data extract). This assumed that patients were being treated by the same general practice during the whole period, so that any mention of HF-specific terms would have appeared during that first year.

For clinical and laboratory data, the most recent measurement was selected for analyses.

Table 1 Hierarchical criteria for stratification and number of patients by group

Group	Criteria[a]	Number of patients
1 Patients who definitively had HF: (*n* 16 930)	1. HF diagnosis recorded in the diagnosis/condition section, or	3193
	2. HF diagnosis recorded or as free text in the notes, or	8744
	3. Having had an HF-specific medication,[b] or	4773
	4. EF reduced (from free text in the notes), or	144
	5. BNP/NT-proBNP above HF cut-offs, or	50
	6. Recorded ejection fraction (EF) < 40%, or	12
	7. EF ≥ 40 to <50% and typical symptoms and signs recorded, or	10
	8. EF ≥ 40 to <50% and use of a loop diuretic	4
2 Patients who had a probable diagnosis of HF: (*n* 4873)	1. EF ≥ 40 to <50%, or	19
	2. Typical symptoms and signs recorded AND any of the following:	
	a. BNP/NT-proBNP in the inconclusive ranges	38
	b. Use of a loop diuretic	4754
	c. Documented EF > 50%	62
3 Patients where HF was possible: (*n* 36 517)	1. Two or more of the less typical symptoms and signs recorded, or	109
	2. Typical symptoms and signs recorded (only), or	36 224
	3. EF > 50% or EF found in notes, but no percentage recorded, or	100
	4. BNP/NT-proBNP in the inconclusive ranges	84

[a]For details, see Parsons *et al.*[6]
[b]In Australia, the following medications have a restricted use benefit in the Pharmaceutical Benefits Scheme to 'moderate to severe heart failure' only: ivabradine; ethacrynic acid; eplerenone; bisoprolol; nebivolol; carvedilol; metoprolol succinate; sacubitril/valsartan. For example: https://www.pbs.gov.au/medicine/item/8733P for metoprolol succinate [doses 23.75, 47.5, 95, and 190 mg (controlled release)].

Regarding medications, if any were taken at any time by a patient during the whole study period, then that patient was identified as having been prescribed those medications. Medications prescribed subsequent to the diagnosis of HF were also reviewed. Only HF-specific medications were used to derive an HF diagnosis.[6] In Australia, HF-specific medications have a 'Restricted Benefit' in the Pharmaceutical Benefits Scheme (Australia's list of subsidized medications) for 'moderate to severe heart failure'. The restriction stipulates that patients must be stabilized on conventional therapy, which must include an angiotensin converting enzyme inhibitor or angiotensin II antagonist, if tolerated.[9] The 'postal area indexes Socio-Economic Indexes for Areas (SEIFA)' data for socio-economic advantage and disadvantage were used for the determinations of socio-economic status (SES).[10]

A Poisson regression model was used to compare the rates of HF for the active patients between age groups, after adjusting for gender and SES quintile. Results of this model were expressed as rate ratios along with their 95% confidence intervals and *P*-values.

Data analyses were conducted using SAS for windows (Version 9.4). The study was approved by the Bellberry Human Research Ethics Committee (Application No. 2018-09-746). The Healius Clinical Council provided governance approval for the study.

Results

Over the 5 year study period, the 43 practices provided care to 2.3 million individual patients, of whom 1.93 million were aged ≥18 years. Of this group, 58 320 patients were classified as having HF—16 930 'definite HF', 4873 'probable HF', and 36 517 'possible HF'—based on a hierarchy of selection criteria (*Table 1*).

Only 3193 (18.9%) of patients with 'definite HF' had the condition recorded in the diagnosis section of their medical records.[8] A further 8744 (51.6%) had the diagnosis recorded in the notes section of their medical record, while 4733 (28.0%) were identified because they were on HF-specific medications, with no HF diagnosis mentioned in their medical records. Most of these patients (4472) were on a single HF-specific medication.[8]

The majority of the 'probable HF' group were identified because they had signs/symptoms of HF and were being treated with a diuretic (4754, 96.6%) but did not have the diagnosis of HF mentioned in their medical records. The majority of the 'possible HF' group (36 224, 99%) were identified because they had two or more of the less typical clinical features of HF recorded.[8] Given the limited sensitivity and specificity of the criteria for 'possible HF', all analyses to describe the prevalence, incidence, and demographics of HF in Australian primary care were undertaken on the combined 'definite' and 'probable' HF groups only. These two groups included a total of 21 803 patients, of whom 20 219 were classified as 'active'.

Of the 1.12 million active patients, the crude prevalence of definite or probable HF was 1.83% (95% CI 1.79–1.84%), and the age-standardized prevalence was 2.20% (95% CI 2.168–2.23%). HF prevalence was 18.80% in men and 16.97% in women in the population aged ≥85 years (*Table 2*). At present, 2.6% of the adult Australian population is aged >85 years (7). The prevalence of 'definite' and 'probable' HF was also higher among people who attended general practices located in areas of lower SES (*Table 3*).

After adjustment for gender and SES quintile, the rates of definite plus probable HF follow the expected pattern for age group (*Table 4*). The reference age group category was 65–74 years. Rates were significantly lower in age younger groups and significantly higher in older age groups. The HF rates in SES Groups 1–4 were all significantly higher than in the highest SES quintile. There was also a slightly higher rate of HF among women, after adjusting for age group and SES.

The crude incidence was 0.227% per year (95% CIs: 0.223–0.231%), and the age-standardized incidence was 0.348% per year (95% CIs: 0.342–0.354%) (*Table 5*). The incidence of HF was 2.250% per year among men and 2.103% per year among women in the population aged ≥85 years.

Based on the above estimates, there would have been 419 378 people living with HF in Australia in 2017, and 66 418 people would have been diagnosed with HF that year (*Table 6*).

Of the active population with a definite or probable diagnosis of HF, the mean [median, inter-quartile range (IQR)] age of patients was 69.9 (72, IQR 59–83) years, 49% were female, and 1.6% were Aboriginal or Torres Strait Islander (*Table 7*). Data on culturally and linguistically diverse (CALD) status (mainly country of birth) were largely missing from the records. Smoking status was missing for 16.9% of this population, but among those for whom data were available, 21.5% were current smokers and 27% were ex-smokers. Body mass index (BMI) data were missing for 38.6% of this population, but among those for whom data were available, average (median, IQR) BMI was 31.2 (30.1, 25.9–35.2). More women had HF in the <55 and ≥85 age groups, while more men had the disease in the age range from 55 to 84 years (*Figure 1*). When standardized to the Australian population, both prevalence and incidence were marginally higher in women compared with men. The total number of men with HF peaked in the 65–74 years age group, but the total number of women with HF continued to increase with age, peaking only in the highest age bracket (≥85 years).

Almost 37% of definite/probable HF patients had no recorded co-morbidities, and 53% had only one to two co-morbidities recorded (*Table 7*). The four most common co-morbidities were hypertension (33% of patients), chronic obstructive pulmonary disease (20%), depression/anxiety

Table 2 Prevalence of heart failure per 100 000, based on the study population, overall and by gender, definite and probable heart failure

		Total adult population			'Active' adult population		
Age group	Group	Number of records (*n*)	Prevalence (per 100 000)	95% confidence interval	Number of records (*n*)	Prevalence per 100 000	95% confidence interval
All ages	Overall	21 803	1128	1113–1143	20 219	1813	1790–1840
(18+)	Male	10 774	1153	1131–1174	9915	1870	1833–1906
	Female	11 029	1105	1084–1125	10 304	1763	1729–1797
18–24	Overall	196	88	75–100	177	144	123–166
	Male	66	63	48–78	59	108	80–136
	Female	130	109	90–128	118	173	142–205
25–34	Overall	628	128	118–138	573	209	192–226
	Male	215	94	81–106	191	156	134–178
	Female	413	158	142–173	382	251	226–276
35–44	Overall	1076	272	256–289	987	436	409–463
	Male	479	239	217–260	419	372	337–408
	Female	597	307	282–332	568	499	458–540
45–54	Overall	2139	701	671–731	1950	1088	1040–1137
	Male	1003	649	608–689	883	979	915–1044
	Female	1136	755	711–799	1067	11 990	1127–1270
55–64	Overall	3509	1454	1406–1502	3232	2232	2155–2309
	Male	1837	1581	1509–1654	1690	2397	2283–2512
	Female	1672	1335	1271–1399	1542	2076	1972–2180
65–74	Overall	4801	2999	2914–3084	4426	4601	4466–4737
	Male	2573	3344	3215–3473	2365	4995	4794–5197
	Female	2228	2680	2569–2791	2061	4220	4039–4402
75–84	Overall	4774	6280	6102–6458	4463	9632	9349–9915
	Male	2476	6919	6647–7192	2304	10 324	9903–10 746
	Female	2298	5711	5478–5945	2159	8990	8610–9369
85+	Overall	4680	11 670	11 335–12 004	4411	17 758	17 234–18 282
	Male	2125	12 576	12 042–13 111	2004	18 805	17 981–19 628
	Female	2555	11 010	10 583–11 437	2407	16 971	16 293–17 649
Age-standardized prevalence of HF per 100 000							
All ages	Overall	21 803	1431.5	1412–1451	20 219	2199	2168–2230
(18+)	Male	10 774	1430	1403–1457	9915	2150	2108–2193
Female	11 029	1433	1406–1460	10 304	2246	2202–2290	

Standardized to the Australian population using figures obtained from the ABS, total population: 19 072 675 of 18–85+ year olds in 2017.

Table 3 Socio-economic status of the active definite and probable heart failure and the total active populations

Variable	HF patients	All patients	Cases per 100 000
Total number of records (%)	20 219 (100)	1 115 087 (100)	
SES quintile group			
Quintile 1 (lowest)	1862 (9.22)	86 706 (7.78)	2147
Quintile 2	2515 (12.47)	123 010 (11.03)	2045
Quintile 3	5034 (24.72)	222 529 (19.57)	2262
Quintile 4	5006 (24.97)	318 580 (28.57)	1571
Quintile 5 (highest)	5693 (28.05)	357 538 (32.06)	1592
Data missing	109 (0.58)	6724 (0.60)	

Table 4 Poisson regression model comparing rates of definite or probable HF among the active cases

Variable	Rate ratio	95% confidence interval	*P*-value
Gender			
Male	1 (reference)		
Female	1.06	1.03–1.09	<0.0001
Age group			
18–24	0.05	0.05–0.06	<0.0001
25–34	0.07	0.06–0.08	<0.0001
35–44	0.13	0.12–0.14	<0.0001
45–54	0.31	0.29–0.33	<0.0001
55–64	0.57	0.55–0.60	<0.0001
65–74	1 (reference)		
75–84	1.77	1.70–1.85	<0.0001
85 or more	2.78	2.67–2.90	<0.0001
SES quintile			
1	1.36	1.30–1.44	<0.0001
2	1.52	1.45–1.59	<0.0001
3	1.81	1.74–1.88	<0.0001
4	1.10	1.06–1.15	<0.0001
5	1 (reference)		

(19%), and diabetes (9%). These were not mutually exclusive, so some patients may have had more than one.

For the combined definite or probable 'active' HF cohort, the most commonly recorded HF diagnostic terms were 'congestive heart failure' (4393, 21.7%), 'heart failure' (2177, 10.8%) and 'cardiac failure' (674, 3.3%).[8] Use of the contemporary terms HFrEF and 'HF with preserved ejection fraction' ('HFpEF') was rare, occurring in only one record and 18 records, respectively.[8] The most commonly prescribed HF-specific medications were bisoprolol (3783, 18.7%),

Table 5 Incidence of heart failure per 100 000, overall and by gender, definite and probable heart failure, per year

		Total adult population			'Active' adult population		
Age group	Group	Number of records (*n*)	Incidence per 100 000	95% confidence interval	Number of records (*n*)	Incidence per 100 000	95% confidence interval
All ages	Overall	14 029	181.5	178.5–184.5	12 968	291	286–296
(18+)	Male	6821	182.5	178–187	6256	295	287.5–302
	Female	7208	180.5	176.5–185	6712	287	280–294
18–24	Overall	184	21	18–24	166	34	29–39
	Male	60	14	11–18	53	24	18–31
	Female	124	26	21–31	113	42	34–49
25–34	Overall	521	27	24–29	485	44	40–48
	Male	180	20	17–23	164	33	28–39
	Female	341	33	29–36	321	53	47–59
35–44	Overall	882	56	52–59	812	90	83–96
	Male	384	48	43–53	335	74	66–82
	Female	498	64	58–70	477	105	95–114
45–54	Overall	1649	135	129–142	1511	211	200–221
	Male	745	120	112–129	663	184	170–198
	Female	904	150	140–160	848	238	222–254
55–64	Overall	2544	263	253–274	2350	406	389–422
	Male	1340	288	273–304	1235	438	414–462
	Female	1204	240	227–254	1115	375	353–397
65–74	Overall	3105	485	468–502	2850	741	714–768
	Male	1628	529	503–555	1493	788	748–828
	Female	1477	444	422–467	1357	695	658–732
75–84	Overall	2846	936	902–970	2642	1426	1371–1480
	Male	1465	1023	971–1076	1354	1517	1436–1598
	Female	1381	858	813–903	1288	1341	1268–1414
85+	Overall	2298	1433	1374–1491	2152	2166	2074–2257
	Male	1019	1508	1415–1600	959	2250	2107–2392
	Female	1279	1378	1302–1453	1193	2103	1984–2222
Age-standardized annual incidence of HF per 100 000							
All ages	Overall	14 029	227	223–231	12 968	348	342–354
(18+)	Male	6821	225	219–230	6256	338	329–346
Female	7208	229	224–235	6712	358	350–367	

Standardized to the Australian population using figures obtained from the ABS, total population: 19 072 675 of 18-85+ year olds in 2017.

Table 6 Estimated prevalent number and annual incidence of HF cases based on the active patient analysis

Australian adult population, 2017	Age-standardized prevalence per 100 000	Estimated HF population	4 year incidence per 100 000	Estimated HF incident cases per annum
19 072 675	2198.8	419 378	1392.94 (annualized = 348)	66 418

carvedilol (957, 4.7%), and nebivolol (736, 3.6%), while the most commonly recorded typical signs/symptoms of HF were 'dyspnoea' (9401, 46.5%) and 'PND' (paroxysmal nocturnal dyspnoea, 550, 2.7%) either singularly or in combination (638, 3.2%).[8] Very few patients with definite or probable HF had the results of important HF investigations recorded in their medical records—echocardiography results were documented in the notes of only 824 (4.1%) patients, while brain natriuretic peptide (BNP) and N-terminal (NT) proBNP testing had been recorded for only 562 (2.8%) and 323 (1.6%) patients, respectively.[8]

For the secondary analyses based on the 'all patient' cohort, the crude prevalence of definite/probable HF was 1.128% (95% CI 1.113–1.143%) and 1.431% (95% CI 1.412–1.451%) when age standardized to the Australian population (*Table 2*). The crude incidence of definite or probable HF was 0.1815% per year (95% CI 0.1785–0.1845%), and the age-standardized incidence was 0.227% per year (95% CI 0.223–0.231%) (*Table 5*). The median age at which patients fulfilled the study criteria for definite or probable HF was 68 years.

Discussion

SHAPE is the first Australian study of HF based on data drawn directly from the Australian community. It estimates that almost 420 000 people in Australia were living with HF in 2017 and >66 000 new cases of HF occurred that year. These numbers are likely to increase with the growing and ageing of the population.

Table 7 Demographic profile of the definite and probable HF population

Variable	Total adult population			'Active' adult population[a]		
	Overall	Male	Female	Overall	Male	Female
Number of records (%)	21 803 (100)	10 774 (49.42)	11 029 (50.58)	20 219 (100)	10 304 (51.0)	9915 (49.0)
Age at diagnosis (median [IQR], mean [SD])	68.0 [56.0–79.0]; 66.3 [16.5]	68.0 [57.0–78.0]; 66.6 [15.5]	68.0 [55.0–80.0]; 66.0 [17.4]	68.0 [56.0-79.0]; 66.5 [16.4]	68.0 [57.0–78.0]; 66.9 [15.4]	68.0 [55.0–80.0]; 66.0 [17.4]
Current age, years (median [IQR], mean [SD])	72.0 [59.0–83.0]; 69.8 [17.0]	72.0 [60.0–82.0]; 70.1 [15.9]	72.0 [58.0–84.0]; 69.4 [18.0]	72.0 [59.0–83.0]; 69.9 [17.0]	72.0 [60.0–82.0]; 70.1 [15.9]	72.0 [58.0–84.0]; 69.5 [18.0]
Age (years)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)
18 to <25	196 (0.90)	66 (0.61)	130 (1.18)	177 (0.9)	59 (0.6)	118 (1.2)
25–34	628 (2.88)	215 (2.0)	413 (3.74)	573 (2.8)	191 (1.9)	382 (3.7)
35–44	1076 (4.94)	479 (4.45)	597 (5.41)	987 (4.9)	419 (4.2)	568 (5.5)
45–54	2139 (9.81)	1003 (9.3)	1136 (10.3)	1950 (9.6)	883 (8.9)	1067 (10.4)
55–64	3509 (16.09)	1837 (17.05)	1672 (15.2)	3232 (16.0)	1690 (17.0)	1542 (15.0)
65–74	4801 (22.02)	2573 (23.9)	2228 (20.2)	4426 (21.9)	2365 (23.9)	2061 (20.0)
75–84	4774 (21.90)	2476 (22.9)	2298 (20.8)	4463 (22.1)	2304 (23.2)	2159 (21.0)
85+	4680 (21.46)	2125 (19.7)	2555 (23.2)	4411 (21.8)	2004 (20.2)	2407 (23.4)
ATSI						
Yes	360 (1.65)	146 (1.36)	214 (1.94)	326 (1.6)	133 (1.3)	193 (1.9)
No	19 527 (89.6)	9658 (89.6)	9869 (89.5)	18 320 (90.6)	8992 (90.7)	9328 (90.5)
Data missing	1916 (8.79)	970 (9.0)	946 (8.6)	1573 (7.8)	790 (8.0)	783 (7.6)
SES quintile group[b]						
Quintile 1 (lowest)	2011 (9.22)	1023 (9.5)	988 (8.9)	1862 (9.2)	943 (9.5)	919 (8.9)
Quintile 2	2718 (12.47)	1269 (11.8)	1449 (13.1)	2515 (12.4)	1163 (11.7)	1352 (13.1)
Quintile 3	5389 (24.72)	2566 (23.8)	2823 (25.6)	5034 (24.9)	2372 (23.9)	2662 (25.8)
Quintile 4	5444 (24.97)	2781 (25.8)	2663 (24.15)	5006 (24.8)	2546 (25.7)	2460 (23.9)
Quintile 5 (highest)	6115 (28.05)	3066 (28.5)	3049 (27.65)	5693 (28.2)	2833 (28.6)	2860 (27.8)
Data missing	126 (0.58)	69 (0.64)	57 (0.52)	109 (0.5)	58 (0.6)	51 (0.5)
CALD status[c]						
Yes	198 (0.98)	101 (0.94)	97 (0.88)	174 (0.9)	90 (0.9)	84 (0.8)
No	1570 (7.2)	728 (6.8)	842 (7.6)	1508 (7.5)	695 (7.0)	813 (7.9)
Data missing	20 035 (91.89)	9945 (92.3)	10 090 (91.5)	18 537 (91.7)	9130 (92.1)	9407 (91.3)
Smoker						
Current	4535 (20.80)	2229 (20.7)	2306 (20.9)	4350 (21.5)	2119 (21.4)	2231 (21.7)
Ex-smoker	5664 (25.98)	3520 (32.7)	2144 (9.4)	5467 (27.0)	3386 (34.2)	2081 (20.2)
Never smoked	7378 (33.84)	2941 (27.3)	4437 (40.2)	6995 (34.6)	2767 (27.9)	4228 (41.0)
Data missing	4226 (19.38)	2084 (19.3)	2142 (19.4)	3407 (16.9)	1643 (16.6)	1764 (17.1)
Weight (median [range], mean [SD])	82.5 [69.0–99.0]; 85.6 [24.3]	88.0 [75.0–104]; 91.7 [23.6]	76.0 [63.0–93.0]; 79.8 [23.5]	82.5 [69.0–99.0]; 85.6 [24.3]	88.0 [75.0–104]; 91.7 [23.6]	76.0 [63.0–93.0]; 79.8 [23.5]
BMI[d] (median [IQR], mean [SD])	30.1 [25.8–35.2]; 31.2 [7.7]	29.8 [26.1–34.4]; 30.7 [6.9]	30.4 [25.6–36.2]; 31.6 [8.4]	30.1 [25.9–35.2]; 31.2 [7.7]	29.8 [26.1–34.4]; 30.7 [6.9]	30.5 [25.6–36.3]; 31.6 [8.4]
Underweight (<19 kg/m^2)	292 (1.34)	77 (0.7)	215 (1.95)	285 (1.4)	75 (0.8)	210 (2.0)
Normal (19–25 kg/m^2)	2318 (10.63)	1071 (9.9)	1247 (11.3)	2277 (11.3)	1043 (10.5)	1234 (12.0)
Overweight (>25–30 kg/m^2)	3612 (16.57)	1939 (18.0)	1673 (15.2)	3564 (17.6)	1909 (19.3)	1655 (16.1)
Obese (>30 kg/m^2)	6375 (29.24)	2934 (27.2)	3441 (31.2)	6281 (31.1)	2881 (29.1)	3400 (33.0)
Data missing	9206 (42.22)	4753 (44.1)	4452 (40.4)	7812 (38.6)	4007 (40.4)	3805 (36.9)
Co-morbidities						

(*Continues*)

Table 7 (continued)

Variable	Total adult population			'Active' adult population[a]		
	Overall	Male	Female	Overall	Male	Female
None	8711 (40.0)	4544 (42.2)	4167 (37.8)	7405 (36.6)	3843 (38.8)	3562 (34.6)
1–2	10 972 (50.3)	5331 (49.5)	5641 (51.2)	10 704 (52.9)	5179 (52.2)	5525 (53.6)
3 or more	2120 (9.7)	899 (8.3)	1221 (11.1)	2110 (10.4)	893 (9.0)	1217 (11.8)

[a]'Active' patients; those with at least three visits per 2 year period.[8]
[b]Socio-economic status (SES) estimated from patient post code only.
[c]Culturally and linguistically diverse (CALD) status according to Australian Bureau of Statistics definitions: www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4529.0.00.003~2014~Main%20Features~Cultural%20and%20Linguistic%20Diversity%20(CALD)%20Characteristics~13.
[d]Body mass index (BMI) calculated as weight (kg)/height(m)^2 or as recorded in the notes.
IQR, inter-quartile range; SD, standard deviation.

SHAPE provides much-needed insight into the landscape of HF in Australian primary care. In a recent modelling study, Chan *et al*. applied international age-and-sex prevalence and incidence estimates to Australian demographic data and estimated the overall prevalence of HFrEF to be 2.1% among Australian adults and the incidence to be 0.27% per year.[5] These estimates excluded HFpEF, while our study made no distinction of HFrEF and HFpEF because, as mentioned, the medical records rarely mentioned these terms. It is difficult to compare the results of our study to that of Chan *et al*. given the disparate approaches to estimating prevalence and incidence. Our study might have underestimated the burden of HFpEF given that this condition is not as well recognized as HFrEF, and there are no specific medications used to treat teat HFpEF.

Our finding that women develop HF at a later age than men is in line with that of other studies.[11,12] We also noted that the prevalence of HF is higher among people from lower socio-economic areas, which also accords with international data.[13]

Of concern, we found that fewer than one in five patients with HF had the condition specifically recorded in the diagnosis section of their GP's medical records. This section of the medical record provides an important summary of co-morbidities, including for other clinicians involved in care. Furthermore, even when diagnoses of HF were noted, the use of the contemporary terms 'HF with reduced ejection fraction' ('HFrEF') and 'HF with preserved ejection fraction' ('HFpEF') was rare. Echocardiographic results were also rarely recorded. This presents an opportunity for improvement—overall management of HF will be enhanced with its greater recognition, documentation, and classification in primary care.

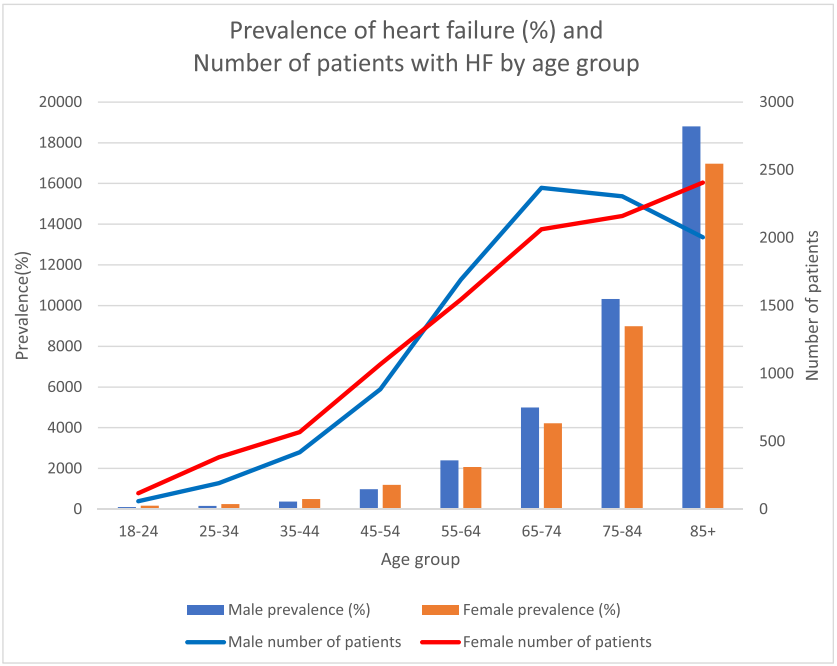
Australia's Federal Department of Health has recognized that the completeness of data recorded in electronic medical systems could be improved widely across general practice. Hence, the Federal Health Department's amendment of its Practice Incentive Program Quality Improvement incentive payments for practice will initially target data quality and reinforce the importance of good coding.[14]

Another finding of concern was the low use of HF-specific medications that have been proven to improve outcomes in patients with HF. Part of this might reflect the under-appreciation of HF among patients, as noted above. Regardless, herein lies another opportunity for improving quality of care.

Strengths and limitations

The major strength of SHAPE lies in its size and involvement of a large number of general practices from across Australia. Also, as mentioned, it is the first study of HF

Figure 1 Prevalence of heart failure (HF) (%) and number of patients with HF by age group, active population



involving data directly drawn from the general Australian community.

In terms of limitations, our study might have underestimated the true burden of HFpEF, as discussed above. Selection bias was also a major limitation. Despite its size, SHAPE involved only bulk-billing practices from a single general practice network that employed Medical Director software. Bulk-billing practices are likely to care for people of lower SES, and perhaps also a more itinerant population. One-off or infrequent attendances are expected to result in medical recording that focuses on the acute presenting complaint and be sparse with regard to the capture of chronic conditions. To account for these, we used the RACGP's definition of 'active' patients (a minimum of three GP visits in a 24 month period) in the primary analyses. Doing so will also have avoided the under-estimation of true prevalence and incidence of HF arising from artificially elevated denominator data.

To minimize selection bias arising from the non-representativeness of our study population in terms of age and gender, our estimates were age standardized to the Australian population (in 2017).

The third major limitation pertained to data misclassification. Although medical record systems in primary care can be well structured, compliance with populating the records in accordance with the intended structure is variable and often incomplete.[15] Also, some data in the records are not available for electronic assessment, as they are not searchable (e.g. discharge summaries and investigation reports contained as scanned documents). Furthermore, the use of programming methods to search free text for specific keywords is an inexact science. We manually reviewed 50 records to refine the search criteria and confirmed that commonly appearing misspellings of words were correctly identified, but it was not feasible to review all patient notes.

For the calculation of incidence, our assumptions that new cases were those that appeared in the database from July 2014 onwards (excluding those that were diagnosed in the first year of the data extract) and that patients were being treated by the same general practice during the whole period may not be valid for a patient with established HF who commenced their interaction with the general practice at some point after July 2014. Thus, our estimated incidence may have been high (as these cases would be considered 'new' by mistake). However, with the large numbers of patients involved, we expect this to have a small influence on the final estimates.

Conclusions

SHAPE is the first real-world study of the epidemiology of HF in Australian primary care. The estimates of prevalence and incidence suggest that almost 420 000 people were living with HF in Australia in 2017, and >66 000 new cases of HF occurred that year. These may be under-estimates given the possibility of not capturing all cases on HFpEF. Quantifying

the epidemiological characteristics of HF in the community provides important insight into a common condition among Australian adults. However, as the vast majority did not have the diagnosis optimally captured in their medical records, efforts to achieve best practice care will be hampered, and better documentation of HF is required in the Australian primary care setting.

Ethics approval and consent to participate

The study was approved by the Bellberry Human Research Ethics Committee (Application No. 2018-09-746). The Healius Clinical Council provided governance approval for the study.

Consent for publication

The authors provide consent to publish this article.

Availability of data and materials

Data, which are derived from de-identified electronic medical records, are not publicly available and will not be made available to the general public. The data were provided by the participating medical centres belonging to an Australian health care company (Healius Ltd), which de-identified the data, removing all potentially identifiable data from the records, and then provided the data to the researchers for analysis. Access to these data was granted by Healius following independent ethics approval of the study and institutional governance approval.

Patient and public involvement

This is a retrospective cohort study based on analysis of existing medical records of patients aged ≥18 years or more cared for at participating general practices. The study utilized techniques to identify potential HF patients who would not have been identified using standard search processes. A list of the relevant unique study-specific codes was sent back to the medical centre group's Chief Medical Officer to allow HF patients to be identified at the centres and then to manage patients as was deemed clinically appropriate.

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Conflict of interest

DL has received honoraria from Amgen, AZ, Bayer, BI, BMS, Novartis, Pfizer, Sanofi, and Shire. PP has sat on advisory boards and/or spoken at, facilitated, or chaired at meetings for and/or received travel and accommodation costs from AbbVie, Amgen, AZ, Bayer, BI, BMS, CSL, Eli Lilly, GSK, Janssen, Menarini, MSD, Novartis, Novo Nordisk, Pfizer, Sanofi, and Seqirus. RA served as a member of several Advisory Boards and conducted paid presentations for AZ, Novartis, and Sanofi in the past 2 years and Abbott, BMS, Eli Lilly, Novo Nordisk, Servier, and Takeda prior to this. DH has given talks for AZ, Bayer, BMS, Novartis, and Pfizer. AS has received honoraria, speaker fees, and consultancy fees and is a member of advisory boards or has appeared on expert panels for Alphapharm, Aspen, AstraZeneca (AZ), Bayer, Biotronik, Boehringer Ingelheim, Bristol Myers Squibb, Janssen Cilag, Menarini, Merck Sharp and Dohme (MSD), Mylan, Novartis, Otsuka, Pfizer, Sanofi, Servier, and Vifor. AusTrials was commissioned by Novartis Pharmaceuticals Australia Pty Ltd to conduct the SHAPE study. AMN and RP are both employees of AusTrials. KL is a full-time employee of Novartis Pharmaceuticals Australia Pty Ltd.

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Author contributions

AS, DL, RA, DH, and KL were involved in the study concept and design. AS, RA, PP, DL, DH, AMN, and RP contributed to the development of the data extraction plan, data analysis, and reporting of the findings. DL, AMN, RP, AS, DH, RA, PP, and KL were involved in drafting and critical revision of the manuscript. All authors read and approved the final version of the manuscript. Novartis Pharmaceuticals Pty Limited and its employees had no role in the data collection, development of the analysis plan, data analyses, or interpretation of the data. KL was involved in the manuscript writing.

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