Financial Costs of Emergency Department Presentations for Australian Patients With Heart Disease in the Last 3 Years of Life

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ABSTRACT: Aims: This study described emergency department (ED) resource use patterns and associated costs among patients with heart disease in their last 3 years of life in a high-income country. **Methods:** This study used linked data from ED and death registry databases in Australia. A random sample of 1000 patients who died due to any cause in 2017, and who had been living with heart disease for at least the prior 10-years were included. The outcomes of interest were number of ED presentations over each of the last 3 years prior to death and relative cost contributions of ED-related items. **Results:** The number of patients needing ED care and number of ED presentations per patient increased as patients were closer to death, with 85% experiencing at least one ED presentation in their last year of life. Mean per patient ED presentation cost increased with each year closer to death. Costs related to labor, pathology, patient travel, and goods and services contributed more than 85% of the total cost in each of the 3 years. **Conclusion:** The increase in cost burden as patients neared death was attributable to more frequent ED presentations per person rather than more expensive ED presentations. The scope of this study was limited to ED presentations, and may not be representative of heart-disease-related end-of-life care more broadly.

KEYWORDS: Heart disease, costs, end of life, emergency, multimorbidity

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Introduction

Cardiovascular disease (CVD), comprising disorders of the heart and blood vessels, is currently the leading global cause of death.[1] In 2016, 17.9 million, or 31% of all deaths globally, were attributed to CVD and is expected to increase to 23.6 million by 2030.[1] Although the burden of CVD is most notable within high income countries, current trends indicate significant increases in the incidence of CVD in low and middle-income countries.[2] Within this broad disease group, conditions related to the heart contribute to nearly 50% to the deaths associated with CVD.[1,3] Of these, ischemic heart disease is the leading single cause of death in most countries.[4] The cost burden to healthcare systems has steadily increased alongside increasing prevalence of heart disease among aging populations internationally.[4]

People with heart disease are surviving longer due in part to improvements in life preserving interventions, but this may mean they experience deteriorating health over long periods of time as they approach death. Longer life and increasing health-state complexity[5] contribute to increase emergency department (ED) presentations.[6] In 2018 it was estimated that patients 65 years or older contributed to 22% of (ED) presentations, a figure which has likely since increased as the proportion of the population living in advanced ages has also increased.[7,8] A study in US veterans reported that each additional body system affected by chronic conditions increases the likelihood of an ED presentation by 40%, compared with only 20% increase in total hospitalizations.[9] Similarly, in Australia, 70% of people who had died of a condition amenable to palliative care, had at least one ED presentation during the final year of life.[10]

ED presentations are expensive, and ED related expenditure is growing internationally,[11,12] particularly among people with ischemic heart disease.[13] Only 32% to 68% of older patients who present to the ED are admitted to hospitals and a significant proportion will be discharged after initial management in the ED,[14] which highlights the importance of investigating ED resource use distinct from general hospitalization resource use. Considering the current significant global burden of heart disease, it is likely that ED presentations by patients with heart disease in their last years of life could be a significant contributor of ED related cost burden in health systems internationally. However, there have not yet been reports of the nature of ED resource use among people with heart disease in the last years of life. Some studies have

investigated specific heart diseases, such as congenital heart disease[15] and atrial fibrillation[16] but were not based on patients' last years of life. Better understanding of the nature of financial costs of ED presentations in this patient population, including a better understanding of the main cost drivers, will provide evidence to plan future high value care models for people with heart disease approaching the end of their life.

The present study outlines the main cost drivers of ED presentations among patients with heart disease in their last 3 year of life in Australia, using linked health service data. This evidence quantifying ED resource usage patterns at end of life among people known to be living with heart disease will assist those seeking to guide policy and care practices regarding provision of end of life care, where recurrent ED presentations, some of which may be avoidable, may not be desirable for patients, families, or healthcare providers and may disproportionately affect patients with disadvantageous social circumstances.[6]

Methods

Study design and population

The study was an observational cohort study utilizing linked administrative data regarding emergency presentations and death in the state of Queensland, Australia (population 5.07 million).[17]

The study sample included patients who had died in Queensland in 2017 and known to be living with heart disease for at least 10 years having had a prior heart disease related hospital admission between 1st January 2000 and 31st December 2007. Ten years was chosen based on the availability of the data sets used in the study and this duration was calculated from the individuals date of death. ICD-10 classifications were used to specify hospital admissions that were related to heart-disease. They included: I20 (Angina pectoris), I21 (Acute myocardial infarction), I22 (Subsequent myocardial infarction), I23 (Certain current complications following acute myocardial infarction), I24 (Other acute ischemic heart diseases), I25 (Chronic ischemic heart disease), I50 (Heart failure), I05 (Rheumatic mitral valve diseases), I06 (Rheumatic aortic valve diseases), I07 (Rheumatic tricuspid valve diseases), I08 (Multiple valve diseases), I09 (Other rheumatic heart diseases). Of the 3439 individuals who met these criteria, a random sample of 1000 individuals were selected using a computerized simple random sampling method to form the study cohort. A random sample of 1000 have relatively little uncertainty. For example, a sample size of 1000 gives a margin of error of 3.1% or less for any prevalence.[18] Further, the random selection of participants means they will be representative of the wider population, making our inferences generalizable to the wider population. Both probabilistic and deterministic data linkage methods were used to link different data sources as described in the Queensland Data Linkage Framework[19] by the Statistical Services Branch of the Queensland Health Department.

Table 1. Patient and clinical characteristics of patients with a cardiac condition (n = 943).

CHARACTERISTICS	
Patient age at death year (n, %)	
20-60 y	42 (4.5%)
60-70 y	95 (10.1%)
70-80 y	268 (28.4%)
80-85 y	198 (21.0%)
>85 y	340 (36.1%)
Sex (n, %)	
Female	375 (39.8%)
Male	568 (60.2%)
Aboriginal and Torres Strait Islander status (n, %)	
No	904 (95.9%)
Yes	37 (3.9%)
Unknown	2 (0.2%)
Residential location at death year (n, %)	
Metropolitan	418 (44.3%)
Inner regional area	204 (21.6%)
Outer regional area	214 (22.7%)
Remote area	63 (6.7%)
Very remote area	44 (4.7%)
Resided in neighborhood with Index of Relative Social Advantage and Disadvantage score in lowest 2 deciles at death year (n, %)	169 (28.5%)
Charlson Comorbidity Index (n, %)	
0 score	171 (18.1%)
1 score	236 (25.0%)
2 score	195 (20.7%)
>2 score	341 (36.2%)

Outcomes

The main outcome of the study was relative contribution of different cost items, shown in Supplemental Table 1, that make up the total cost of ED presentations over each of the last 3 years prior to death. Secondary outcomes included principal diagnosis of the ED presentations and the number of ED presentations over each of the last 3 years prior to death.

Data sources

Four existing data sources were linked which provided complete ED presentation information of the last 3 years of life.

Government Death Registration Data collection. Details on the deaths of individuals, which included date of death, place of death, and cause of death, were accessed from this dataset.

Queensland Health Emergency Department Data Collection. The Queensland Health Emergency Department Data Collection is a database providing information on all emergency presentations in Queensland. For those in the study cohort, information on ED presentations from 1st January 2014 to 31st December 2017, were linked from Queensland Health Emergency Department Data Collection database. This information included, date of presentation and discharge, and principal diagnosis.

Queensland Hospital Admitted Patient Data Collection. Queensland Hospital Admitted Patient Data Collection is a record of all hospital admissions in Queensland. For this particular study, following variables were extracted from this data collection: patient age in years, sex, indigenous status, postcode of usual residence, ICD code of the principal diagnosis of the hospital admissions (this was used to calculate the Charlson Comorbidity Index; see section on data analysis).

National Hospital Costing Data Collection. The National Hospital Costing Data Collection is a database of costing information that includes all hospital admissions and ED presentations in Queensland.[20] Hospital resource use was costed by applying the Independent Hospital Pricing Authority Hospital Patient Costing Standards Version 3.1 (July 2014).[21] These costing standards meet the hospital costing standards mandated by the Commonwealth of Australia. At each inpatient (hospital admissions and ED presentations) encounter, the cost information of each patient was collected according to the aforementioned Hospital Patient Costing Standards and reported by the hospital Finance Department for each hospitalization. It is noteworthy that this costing method is transparent and robust but complex with a substantial volume of explanatory documentation.[21]

For patients in the study cohort, records on all ED presentations identified in the Queensland Health Emergency Department Data Collection were linked to cost data from the National Hospital Costing Data Collection. The information acquired included different National Hospital Costing Data Collection line items, and their cost. Broad categories of cost items included all ED presentation costs related to blood products, imaging, pathology, pharmacy, prostheses, all other medical and surgical supplies, cost of labor, patient travel, hotel goods and services, all other goods and services, depreciation, lease costs, and other. Detailed description of each of the cost item are given in Supplemental Table 1.

Data analysis

Descriptive statistics were used to describe the cohort's characteristics. Continuous variables were presented as mean ± standard deviation, and dichotomous or categorical variables were presented numerically and as percentages. Index of Relative Social Advantage and Disadvantage[22] and Charlson Comorbidity Index were used to describe the cohort and the cost of ED presentations. Index of Relative Social Advantage and Disadvantage is an index summarizing the socio-economic conditions of the neighborhood where participants lived.[22] This index is calculated based on residential address and incorporates indicators of socio-economic advantage and disadvantage, with the lowest 2 deciles adopted as an indicator of patients living in a neighborhood with most disadvantaged socio-economic conditions. The Charlson Comorbidity Index is a validated, weighted index of multimorbidity and the index estimate for this study was derived from ICD 10 diagnosis codes of the main diagnosis of previous hospital admissions, consistent with a previously reported methodology.[23,24] Higher Charlson Comorbidity Index is indicative of more comorbidity. The number of ED presentation and costs were summed and reported by a 12 month period from the date of each individual's death. The total ED presentation cost was calculated as the sum of direct and overhead costs. The National Hospital Costing Data Collection cost item classification was used to describe the ED presentation costs and is presented in Supplemental Table 1. Furthermore, per patient and per hospital costs were also estimated. Per patient cost was estimated by dividing the total cost by the number of patients (n = 943). This cost included the total cost a patient incurred per year from multiple ED presentations. Per presentation cost was estimated by dividing the total cost by the number of ED presentations.

Ethics

Institutional ethics committee approval was obtained through the Royal Brisbane and Women's Hospital Research Ethics Committee (Reference no. HREC/18/QRBW/390) and additional approvals, including approval under Public Health act (Ref: QCOS/033343/RD007999) were given by the data custodians and Queensland Department of Health.

Results

Of the total study sample, 943 (94%) had at least one ED presentation during the last 3 years of life and are described in Table 1. A majority (57%) were over the age of 80 at the time of death, were male (60%) and did not identify as Indigenous Australians (96%). More than one third of patients (36%) had a Charlson Comorbidity Index more than 2. Also, 30% of the cohort were living in 2 lowest deciles of socio-economically advantaged neighborhoods, indicating people from disadvantaged neighborhoods were overrepresented.

The frequency and cost of ED presentations, by Charlson Comorbidity Index category, are summarized in Table 2. The number of patients with at least one ED presentation and mean/median ED presentations per patient, increased when the patients were closer to death and were higher as Charlson Comorbidity Index was higher. More than 75% of the patients in each of the Charlson Comorbidity Index categories had at

Table 2. Frequency and cost of ED patient presentation, according to Charlson Comorbidity Index.

CHARLSON COMORBIDITY INDEX	YEARS TO DEATH	EMERGENCY DEPARTMENT PRESENTATION (EDP)							
		FREQUENCY			COST (AUD)				
		NO OF PATIENTS WITH AT LEAST 1 EDP (%)	MEAN EDP PER PATIENT (SD)	MEDIAN EDP PER PATIENT (IQR)	MEAN EDP COST PER PATIENT (SD)	MEDIAN EDP COST PER PATIENT (IQR)	MEAN EDP COST PER PRESENTATION (SD)	MEDIAN EDP COST PER PRESENTATION (IQR)	TOTAL COST
0 score (n=171)	2	75 (43.8)	0.7 (±1.1)	0 (0-1)	$576.9 (±994.7)	$0 (0-919.4)	$835.2 (±589.5)	$793.7 (531.2-1029.8)	$111 914.1
	1	89 (52.0)	1.0 (±1.6)	0 (0-1)	$891.1 (±1509.9)	$0 (0-1291.8)	$909.9 (±554.9)	$813.7 (585.7-1132.2)	$172 874.3
	0	127 (74.2)	1.9 (±2.7)	1 (0-3)	$1800.3 (±2495.9)	$1138.5 (0-2552.6)	$933.9 (±602.6)	$839.9 (575.0-1171.9)	$349 267.3
1 score (n=236)	2	112 (47.4)	1.0 (±1.7)	0 (0-1)	$941.7 (±1601.3)	$0 (0-1274.3)	$900.9 (±486.8)	$843.4 (600.0-1166.1)	$228 825.7
	1	135 (57.2)	1.5 (±2.2)	1 (0-2)	$1349.2 (±2025.9)	$654.7 (0-1966.9)	$878.9 (±410.9)	$867.5 (613.9-1096.9)	$323 425.0
	0	198 (83.8)	3.0 (±3.0)	2 (1-4)	$2904.7 (±3153.7)	$2173.0 (844.4-3927.1)	$973.6 (±655.9)	$882.1 (642.9-1148.3)	$609 648.7
2 score (n=195)	2	115 (58.9)	1.4 (±2.5)	1 (0-2)	$1126.0 (±2147.9)	$441.2 (0-1458.2)	$799.3 (±488.5)	$807.6 (459.0-1117.8)	$234 208.5
	1	113 (57.9)	1.9 (±3.3)	1 (0-2)	$1554.9 (±2736.0)	$662.1 (0-2091.1)	$825.1 (±507.9)	$807.3 (467.6-1076.3)	$327 845.5
	0	170 (87.1)	3.1 (±3.3)	2 (1-4)	$2931.0 (±3033.0)	$2157.1 (737.2-4264.3)	$945.2 (±665.5)	$847.3 (587.5-1130.3)	$705 844.9
>2 score (n=341)	2	194 (56.8)	1.8 (±4.8)	1 (0-2)	$1391.1 (±3110.5)	$414.5 (0-1632.8)	$779.0 (±500.7)	$741.2 (433.9-1013.8)	$486 876.0
	1	199 (58.3)	1.9 (±3.8)	1 (0-2)	$1531.0 (±2874.5)	$599.7 (0-2088.2)	$803.4 (±486.1)	$761.5 (504.6-1040.6)	$535 855.4
	0	311 (91.2)	3.9 (±4.2)	3 (1-5)	$3780.0 (±4201.4)	$2699.6 (1065.7-4976.9)	$972.8 (±929.6)	$843.7 (606.1-1125.5)	$1 322 994.0

Table 3. Principal diagnosis of ED presentation during last 3 years of life.

DIAGNOSIS	NUMBER (N = 5890)	PERCENTAGE
Symptoms, signs, and abnormal clinical and laboratory findings (R00-R99)	918	15.6
Injury, poisoning, and external causes (S00-T98)	872	14.8
Respiratory diseases (J00-J99)	691	11.7
Ischemic heart diseases (I20-I25)	491	8.3
Factors influencing health status and contact with health services (Z00-Z99)	450	7.6
Other circulation, excluding ischemic heart diseases and heart failures (I00-I99)	372	6.3
Digestive diseases (K00-K93)	368	6.3
Heart failures (I50)	361	6.1
Genitourinary diseases (N00-N99)	339	5.8
All other diagnoses	1028	17.5

least one ED presentation in the last year of life. This was elevated to more than 90% when the Charlson Comorbidity Index was >2. Similarly, the per patient mean and median ED presentation cost, and total cost also increased with fewer years to death and higher Charlson Comorbidity Index. This is evident as the mean ED presentation cost per patient increased by 212% from 2 years to death to last year of life for those with a Charlson Comorbidity Index score of 0 and increased by 173% for those with an index score >2. The mean per ED presentation cost did not change substantially with either the Charlson Comorbidity Index or number of years to death. The mean cost of ED presentation ranged from $779 to $972 in the last 3 years of life.

Table 3 outlines the principal diagnosis of the ED presentations during the patient's last 3 years of life. The most frequent primary diagnosis for ED presentation was associated with *symptoms, signs, and abnormal clinical laboratory findings* which comprised 15.6% of all ED presentations, followed closely by diagnoses associated with *injury, poisoning and external circumstances* at 14.8%. Similarly, 21% of principal diagnoses were related to *cardiovascular disease*. This included ischemic *heart diseases, heart failure, and diagnoses associated with circulation*, with the highest proportion attributed to ischemic *heart diseases* (8.3%).

The disbursement of different cost items of ED presentations during last 3 years of life are outlined in Table 4. There was a substantial increase in total costs in the sample from 1 year to death ($1.4 million) to last year of death ($2.9 million). This is an increase of 110% in total cost, whereas only an increase of 24% in total costs when compared with second year to death to 1 year to death.

Costs related to labor, pathology, patient travel, and goods and services (except hotel goods and services), contributed more than 85% of the total cost in each of the 3 years. Medications contributed less than 2% of the total cost. The major contributor (70%) was cost of labor. Labor cost of the medical staff, including specialist and general practice medical officers, visiting medical officers, registrar, residents, and interns, constituted nearly 48% of the total cost of labor, followed by labor cost of nurses, which was approximately 35%.

Per patient cost and total cost generally increased as patients approached their time of death. The total cost of each cost item doubled in the last year of life, compared to the cost of 1 year prior to death. The highest cost increment was seen in blood products followed by medications, which increased by more than 200% and 170%, respectively.

Per patient costs did not increase substantially for drugs, pathology, prostheses, and blood products over the years. Compared to the costs of 1 year prior to death, per patient cost increment for blood products, imaging, pathology, and drugs in the last year of life was $54, $44, $57, and $27, respectively. However, increment considering cost of labor for medical staff and nurses were $312 and $214, respectively. Interestingly, there was a 176% increase in the per patient cost for the labor of other staff categories in the last year of life compared to 2 years prior to death. Other staff categories included personal care staff at ED such as attendants, ward helpers, assistants, or assistants in nursing.

Furthermore, the increment of per ED presentation cost of different cost items, over the years, is negligible and per presentation cost of some cost items in the last year of life remained almost unchanged from 2 years prior to death (eg, imaging, pathology, salary of the nursing staff).

Discussion

Specialized emergency care provision in hospital EDs remains a central tenet of contemporary healthcare systems with particular importance for people with heart disease; however, ED care is both high-cost and a scarce healthcare resource. This study was the first to investigate ED presentation patterns and associated ED costs among people with heart disease in their last years of life. The rate of ED presentations increased closer to the time of death, and consequently, per patient costs of ED presentations gradually increased over the final years of life due

Table 4. Cost of different cost items during last 3 years of life.

NHCDC COST ITEM	YEARS TO DEATH											
	2Y				1Y				LAST YEAR OF LIFE			
	NO OF PATIENTS (%) (N = 943)	COST (AUD)# (% OUT OF TOTAL COST)	PER PATIENT COST (AUD)	PER PRESENTATION COST (AUD) N = 1306	NO. OF PATIENTS (%) (N = 943)	COST (AUD)# (% OUT OF TOTAL COST)	PER PATIENT COST (AUD)	PER PRESENTATION COST (AUD) N = 1622	NO OF PATIENTS (%) (N = 943)	COST (AUD)# (% OUT OF TOTAL COST)	PER PATIENT COST (AUD)	PER PRESENTATION COST (AUD) N = 3104
Blood products	131 (13.9)	$5000 (0.4)	$36	$4	150 (15.9)	$12 000 (0.9)	$82	$7	272 (28.8)	$37 000 (1.3)	$136	$12
Imaging	365 (38.7)	$40 000 (3.6)	$110	$31	421 (44.6)	$35 000 (2.5)	$82	$22	623 (66.1)	$79 000 (2.7)	$127	$25
Pathology	426 (45.2)	$60 000 (5.5)	$141	$46	510 (54.1)	$72 000 (5.3)	$142	$44	768 (81.4)	$153 000 (5.3)	$199	$49
Medications	469 (49.7)	$13 000 (1.2)	$28	$10	525 (55.7)	$18 000 (1.3)	$34	$11	791 (83.9)	$48 000 (1.7)	$61	$15
Prostheses	432 (45.8)	$400 (0.04)	$1	$0.3	437 (46.3)	$500 (0.04)	$1	$0.3	653 (69.2)	$1000 (0.05)	$2	$0.3
All other medical and surgical supplies (excluding prostheses and drugs)	470 (49.8)	$31 000 (2.8)	$65	$24	526 (55.8)	$43 000 (3.2)	$82	$27	790 (83.8)	$83 000 (2.9)	$105	$27
Cost of labor												
Medical	475 (50.4)	$447 000 (40.7)	$942	$342	530 (56.2)	$437 000 (32.0)	$825	$269	791 (83.9)	$899 000 (31.4)	$1137	$290
Nursing	475 (50.4)	$272 000 (24.7)	$572	$208	529 (56.1)	$340 000 (24.9)	$642	$210	791 (83.9)	$677 000 (23.6)	$856	$218
Allied health	435 (46.1)	$38 000 (3.5)	$88	$29	525 (55.7)	$59 000 (4.3)	$113	$36	789 (83.7)	$116 000 (4.0)	$147	$37
Other staff	474 (50.3)	$57 000 (5.2)	$121	$44	530 (56.2)	$117 000 (8.6)	$221	$72	792 (84)	$265 000 (9.2)	$334	$85
Patient travel	470 (49.8)	$56 000 (5.1)	$118	$43	521 (55.2)	$78 000 (5.7)	$150	$48	781 (82.8)	$185 000 (6.5)	$237	$60
Hotel goods and services	470 (49.8)	$8000 (0.8)	$18	$6	529 (56.1)	$13 000 (1.0)	$25	$8	792 (84)	$27 000 (0.9)	$34	$9
All other goods and services	473 (50.2)	$48 000 (4.4)	$102	$37	530 (56.2)	$104 000 (7.6)	$197	$64	792 (84)	$223 000 (7.8)	$282	$72
Depreciation												
Building	336 (35.6)	$7000 (0.6)	$20	$5	483 (51.2)	$18 000 (1.3)	$37	$11	766 (81.2)	$41 000 (1.4)	$54	$13
Equipment	470 (49.8)	$14 000 (1.3)	$31	$11	529 (56.1)	$18 000 (1.3)	$34	$11	784 (83.1)	$33 000 (1.2)	$43	$11
Leasing costs	51 (5.4)	$20 (<0.001)	$0	$0.0	7 (0.7)	$1 (<0.001)	$0	$0	0 (0)	$0 (0)	$0	$0
Other	27 (2.9)	$0 (0)	$0	$0	4 (0.4)	$0 (0)	$0	$0	0 (0)	$0 (0)	$0	$0
Total		$1 099 000 (100.0)				$1 366 000 (100.0)				$2 869 000 (100.0)		

#Costs are rounded to the nearest AUD 1000.

to this greater frequency of ED presentations. The highest number of ED presentations and average per patient costs occurred in the last year of life. However, mean cost per ED presentation did not change substantially as patients approached the end of their life. The primary drivers of ED presentation costs were labor, pathology, patient travel, and goods and services, which constitute around 85% of the total ED related costs. Mean cost of total per ED presentation and mean cost per ED presentation of different items did not change substantially as patients approached their end of life.

Although there are no directly comparable studies that have previously reported ED resource use and costs for people with heart disease in the last years of life, findings of the present study are consistent with prior research in the field more broadly. It has previously been reported that people with heart disease are more likely to be severely symptomatic in their last years of life which may contribute to elevated ED presentation rates specifically related to cardiovascular conditions.[25] Patients with heart disease may also become increasingly frail in their last years of life, which may contribute to ED presentations for other reasons, including falls and injuries.[26] Additionally, complex comorbid health states and multimorbidity may contribute to elevated rate of ED presentations, which was consistent with findings reported in this study.[6]

Direct comparable studies reporting resource use in ED presentations are scarce in the literature. However, it is well established that, irrespective of the disease entity, care of the patients in their last years of life imposes a substantial cost burden on health systems. Leniz et al[27] reviewed costing studies among dementia patients approaching the end of life. The systematic review reported that the monthly total hospital cost of care increased toward death, from $1787 to USD 2999 in the last 12 months and from $4570 to USD 11921 in the last month of life. Bramley et al studied the end of life cost for metastatic breast cancer patients in The USA, and they reported that patients in end-of-life had 4.15 times higher 6-month total healthcare costs than a non-end of life cohort. The monthly cost of a patient who is in the non-end of life cohort changed between $2336 and $3145, while that of those who are at the end of life cohort increased steadily from $8956 in the sixth month prior to death to $19 326 in the last month of life.[28]

There are several important implications arising from this study. These findings highlight the importance of ongoing efforts in clinical practice and research to reduce the frequency of potentially avoidable ED presentations among people with heart disease as they approach the end of their life. There are at least 3 pillars of support that continue to have relevance in the field here in light of this study and broader literature in the field. The first is perhaps appropriate secondary prevention in clinical practice to minimize acute exacerbations of cardiovascular conditions requiring presentation to ED.[10] The second is ensuring that appropriate end-of-life care planning is in place for those known to be approaching the end of their life to enable people to die without ED presentations that they do not desire. This may occur on account of a defensive posture from well-intentioned care providers that is misaligned with the preferences of patients. The third is the role of ensuring people with heart disease have access to appropriate health and social welfare supports more broadly in the context managing the complex health states often experienced as they approach the end of their life. This includes the integration of primary, secondary, and tertiary healthcare services, as well integration with social welfare supports to enable people to avoid unnecessary ED visits, particularly among people who are frail or who may have substantial multimorbidity.[29-31] Further development, implementation, and refinement of clinical care models that have potential to promote integrated safe and efficient care, including hospital in the home and integrated virtual care models remain a priority.[32]

The present study does add some weight to the importance of considering the appropriateness of ED presentations among people with heart disease. However, an important limitation of the present study was that we were not seeking to classify the appropriateness of ED presentations captured within our dataset, which was considered beyond the intended scope of this study. Nonetheless, it is noteworthy that a prior systematic review of non-beneficial hospital care that included 38 studies reported 33% to 38% of patients near their end of life had received non-beneficial treatments, including ED presentations.[33] Non-beneficial care at end-of-life may not only be detrimental to health system efficiency[34] but may be associated with physical and psychological harm for patients and remains a priority for ongoing research.

There are some other notable strengths and limitations of this study. First, the data linkage approach using state-wide large well-curated datasets enabled the selection of random sample likely to be representative of the underlying population. While this may be considered a strength, this also meant that variables available for inclusion in the present study were limited by the nature of the existing underlying data collections. Second, the study cohort was limited to patients who died in 2017 and had a heart disease-related hospital admission between January 2000 and December 2007, inclusive. This would not have included any patients who had a hospital admission within those years but died before 2017 due to rapidly progressing disease or a sudden catastrophic health event. Third, by design, the study included only ED costs and these findings may not generalize to primary care or hospital costs accrued after the initial ED presentation. Thus, the study does not represent total health system costs, nor patient out of pocket costs, which were not within the scope of the present study. Fourth, the study population was defined as patients who had died in Queensland in 2017 and known to be living with heart disease for at least 10 years, having had a prior heart disease-related hospital admission between 1st January 2000 and 31st December 2007. Therefore anyone who did not require hospital admission after a heart disease were not included in the data set. Therefore, the cost estimates presented may not represent the entire disease spectrum of heart disease.

Conclusion

The number of patients needing ED care and number of ED presentations per patient increased as patients were closer to death and had multiple comorbidities. The increase in cost burden as patients neared death was attributable to more frequent ED presentations per person rather than more expensive ED presentations. Clinical care models that have potential to promote integrated safe and efficient care, including hospital in the home and integrated virtual care models remain a priority for patients with heart disease during their last years of life.

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Author Contributions

SK: Conception and design, data acquisition, data interpretation, and critically revised the manuscript. JW: Data analysis and drafted the manuscript. SS: Conception and design, data analysis and interpretation, and drafted the manuscript. DB: Conception and design, data interpretation, and critically revised the manuscript. JG: Conception and design, data interpretation, and critically revised the manuscript. WP: Conception and design, data interpretation, and critically revised the manuscript. DJ: Conception and design, and data analysis and interpretation. SM: Conception and design, data interpretation, and critically revised the manuscript. All authors gave their final approval and agreed to be accountable all aspects of work ensuring integrity and accuracy.

Ethics

Institutional ethics committee approval was obtained through the Royal Brisbane and Women's Hospital Research Ethics Committee (Reference no. HREC/18/QRBW/390) and additional approvals, including approval under Public Health act (Ref: QCOS/033343/RD007999) were given by the data custodians and Queensland Department of Health.

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Supplemental Material

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REFERENCES

1. World Health Organization. Cardiovascular diseases (CVDs). 2017. Accessed February 2, 2021. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)
2. Celermajer DS, Chow CK, Marijon E, Anstey NM, Woo KS. Cardiovascular disease in the developing world: prevalences, patterns, and the potential of early disease detection. *J Am Coll Cardiol*. 2012;60:1207-1216.
3. Nicols M, Peterson K, Alston L, Allender S. *Australian Heart Disease Statistics 2014*. National Heart Foundation of Australia; 2014. Accessed February 2, 2021. https://www.heartfoundation.org.au/images/uploads/main/Your_heart/RES-113_Aust_heart_disease_statistics_2014_WEB.PDF
4. National Heart Foundation of Australia. *Heart Disease Fact Sheet*. National Heart Foundation of Australia; 2021. Accessed February 2, 2021. https://www.heartfoundation.org.au/about-us/what-we-do/heart-disease-in-australia/heart-disease-fact-sheet
5. Tyack Z, Frakes KA, Barnett A, Cornwell P, Kuys S, McPhail S. Predictors of health-related quality of life in people with a complex chronic disease including multimorbidity: a longitudinal cohort study. *Qual Life Res*. 2016;25:2579-2592.
6. McPhail S. Multimorbidity in chronic disease: impact on health care resources and costs. *Risk Manag Healthc Policy*. 2016;9:143-156.
7. Australian Institute of Health and Welfare. 2018. Emergency Department Care 2017–18: Australian Hospital Statistics. AIHW; 2018. Report No.: Health services series no. 89. Cat. no. HSE 216.
8. Braes T, Moons P, Lipkens P, et al. Screening for risk of unplanned readmission in older patients admitted to hospital: predictive accuracy of three instruments. *Aging Clin Exp Res*. 2010;22:345-351.
9. Zulman DM, Pal Chee C, Wagner TH, et al. Multimorbidity and healthcare utilisation among high-cost patients in the US Veterans Affairs Health Care System. *BMJ Open*. 2015;5:e007771.
10. Rosenwax LK, McNamara BA, Murray K, McCabe RJ, Aoun SM, Currow DC. Hospital and emergency department use in the last year of life: a baseline for future modifications to end-of-life care. *Med J Aust*. 2011;194:570-573.
11. The Independent Hospital Pricing Authority. National hospital cost data collection cost report: round 20 financial year 2015-16. 2018. Accessed March 15, 2021. https://www.ihpa.gov.au/sites/default/files/publications/nhcdc_cost_report_round_20_financial_year_2015-16_0.pdf
12. Saber Tehrani AS, Coughlan D, Hsieh YH, et al. Rising annual costs of dizziness presentations to US emergency departments. *Acad Emerg Med*. 2013;20:689-696.
13. Chan DK, Chong R, Basilikas J, Mathie M, Hung WT. Survey of major chronic illnesses and hospital admissions via the emergency department in a randomized older population in Randwick, Australia. *Emerg Med Aust*. 2002;14:387-392.
14. McCusker J, Verdon J. Do geriatric interventions reduce emergency department visits? A systematic review. *J Gerontol A*. 2006;61:53-62.
15. Lu Y, Agrawal G, Lin C-W, Williams RG. Inpatient admissions and costs of congenital heart disease from adolescence to young adulthood. *Am Heart J*. 2014;168:948-955.
16. Rozen G, Hosseini SM, Kaadan MI, et al. Emergency department visits for atrial fibrillation in the United States: Trends in admission rates and economic burden from 2007 to 2014. *J Am Heart Assoc*. 2018;7:e009024.
17. Queensland Government. *Queensland Population Counter Queensland Government Statistician's Office*. Queensland Government; 2020. Accessed August 27, 2020. https://www.qgso.qld.gov.au/statistics/theme/population/population-estimates/state-territories/qld-population-counter
18. Rossi PH, Wright JD, Anderson AB. *Handbook of Survey Research*. Academic Press; 2013.
19. Queensland Health. *Queensland Data Linkage Framework Queensland*. Queensland Health; 2017. Accessed March 12, 2020. https://www.health.qld.gov.au/__data/assets/pdf_file/0030/150798/qlddatalinkframework.pdf
20. Independent Hospital Pricing Authority. *Australian Hospital Patient Costing Standards – Part 1: Standards – Version 4.0*. Independent Hospital Pricing Authority. 2018. Accessed March 13, 2020. https://www.ihpa.gov.au/sites/default/files/publications/australian_hospital_patient_costing_standards_-_version_4.0_-_part_1_-_standards.pdf
21. Independent Hospital Pricing Authority (IHPA). *Australian Hospital Patient Costing Standards Version 3.1*. Independent Hospital Pricing Authority (IHPA); 2014. Accessed March 12, 2022. https://www.ihpa.gov.au/sites/default/files/publications/ahpcs-version3.1.pdf?acsf_files_redirect
22. Australian Bureau of Statistics. *Socio-Economic Indexes for Areas*. Australian Bureau of Statistics; 2018. Accessed March 3, 2021. https://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa
23. Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care*. 2005;43:1130-1139.
24. Thygesen SK, Christiansen CF, Christensen S, Lash TL, Sørensen HT. The predictive value of ICD-10 diagnostic coding used to assess Charlson comorbidity index conditions in the population-based Danish National Registry of Patients. *BMC Med Res Methodol*. 2011;11:83.
25. Warraich HJ, Hernandez AF, Allen LA. How medicine has changed the end of life for patients with cardiovascular disease. *J Am Coll Cardiol*. 2017;70:1276-1289.
26. Papathanasiou JV. Are the group-based interventions improving the functional exercise capacity and quality of life of frail subjects with chronic heart failure?

Journal of Frailty, Sarcopenia and Falls. 2020;5:102-108.
27. Leniz J, Yi D, Yorganci E, et al. Exploring costs, cost components, and associated factors among people with dementia approaching the end of life: A systematic review. *Alzheimers Dement Transl Res Clin Interv*. 2021;7:e12198.
28. Bramley T, Antao V, Lunacsek O, Hennenfent K, Masaquel A. The economic burden of end-of-life care in metastatic breast cancer. *J Med Econ*. 2016;19:1075-1080.
29. Zhang Z, Tumin D. Expected social support and recovery of functional status after heart surgery. *Disabil Rehabil*. 2020;42:1167-1172.
30. Chamberlain L. Perceived social support and self-care in patients hospitalized with heart failure. *Eur J Cardiovasc Nurs*. 2017;16:753-761.
31. Liu M-H, Wang C-H, Tung T-H, Lee C-M, Chiou A-F. Care needs, social support and meaning in life in patients after acute heart failure hospitalisation: a longitudinal study. *Eur J Cardiovasc Nurs*. 2021;20:106-114.
32. Coast J, Richards SH, Peters TJ, Gunnell DJ, Darlow M-A, Pounsford J. Hospital at home or acute hospital care? A cost minimisation analysis. *BMJ*. 1998;316:1802-1806.
33. Cardona-Morrell M, Kim J, Turner RM, Anstey M, Mitchell IA, Hillman K. Non-beneficial treatments in hospital at the end of life: a systematic review on extent of the problem. *Int J Qual Health Care*. 2016;28:456-469.
34. Aghabarary M, Dehghan Nayeri N. Medical futility and its challenges: a review study. *J Med Ethics Hist Med*. 2016;9:11.